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VOLUME 25 MARCH, 1951 NUMBER 2

TERTIARY FORAMINIFERA OF COASTAL ECUADOR: PART I, EOCENE[1]

JOSEPH A. CUSHMAN AND R. M. STAINFORTH

Cushman Laboratory for Foraminiferal Research and International Petroleum Company, Talara, Peru

ABSTRACT—Type localities are designated for 59 zonal units recognizable in the Tertiaries of western Ecuador. The Foraminifera from the 12 Eocene units are described.

STRATIGRAPHIC INTRODUCTION

MICROPALEONTOLOGICAL studies in coastal Ecuador by International Ecuadorean Petroleum Company were recently summarized (Stainforth, 1948). Preliminary studies of the faunas were made by D. L. Frizzell and F. Putlitz under the direction of H. E. Thalmann, and later detailed zonal analyses were made by A. Martinez, R. M. Stainforth, F. V. Stevenson and B. Stone. The present paper is concerned with the systematic details of Tertiary foraminiferal assemblages encountered in these studies. The faunal descriptions are based on analyses of washed residues from the chosen type localities of 59 zonal units. The stratigraphic relationships of these units are shown on the chart (fig. 1) and their geographic positions on the maps (figs. 2, 3, 4). Further details follow. The zero point of the geographic coordinates is the Plaza del Centenario monument in Guayaquil.

[1] At the time of his widely regretted death Dr. Cushman was working on the systematic description of foraminiferal faunas selected by the junior author as representative of the entire faunal succession in the Tertiaries of western Ecuador. The original intention was to publish the results as a single paper, but it now becomes expedient to issue this first part, dealing only with the Eocene faunas, and to defer publication of a second part on the Oligo-Miocene faunas until arrangements can be made for completion of Dr. Cushman's unfinished studies. The stratigraphic introduction, as well as the maps and stratigraphic chart, will be applicable to the entire paper. Cordial thanks are here expressed to Miss Ruth Todd and Miss Rita Johnson for much assistance in picking and mounting the Foraminifera and in the preparation of the text and plates. Grateful acknowledgment is also made to the International Petroleum Company for permitting publication of this paper.

UNIT 1

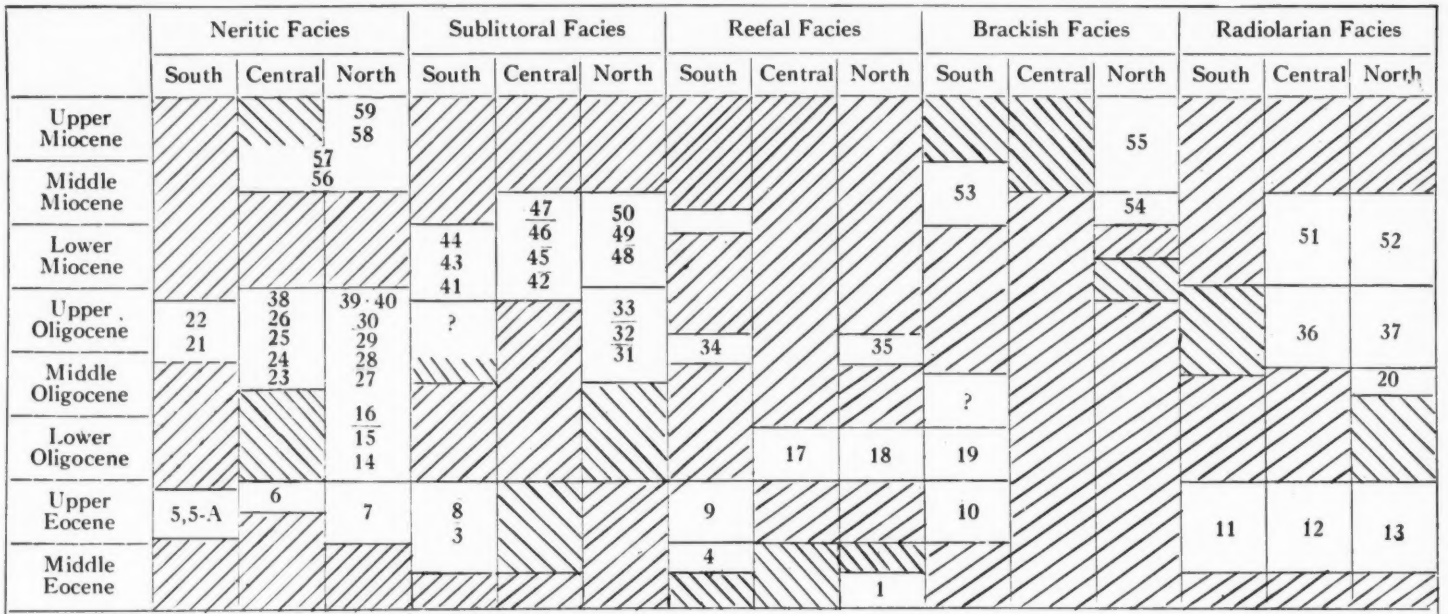
Age.—Lower middle Eocene.

Formation.—San Eduardo.

Facies.—Reefal.

Area.—North.

Locality.—The type locality of "*Amphistegina elliotti* Cushman and Stainforth" = *Helicostegina*, namely Estero Pollo, a small tributary on the left side of Rio Verde some 22.5 km. in a straight line from the river mouth. The outcrop is a massive algal-orbitoid limestone, but washable ma-



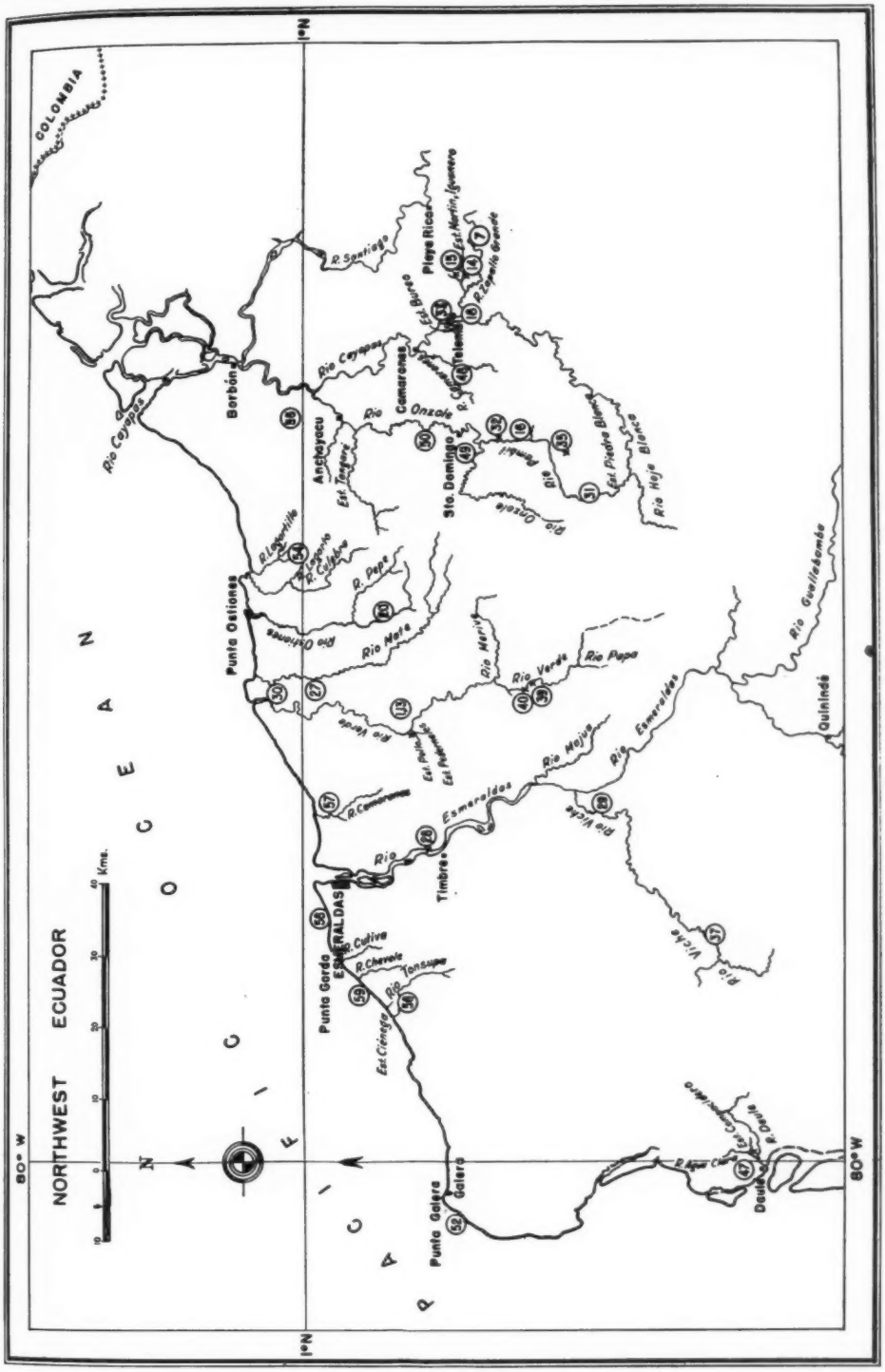
MICROFAUNAL UNITS OF COASTAL ECUADOR

Chart showing the age-, facies- and geographic relationships of the Tertiary foraminiferal assemblages discussed in this paper.

Corresponding age-facies unit not known in the area indicated.

Corresponding age-facies unit known or inferred in the area indicated, but available material not suitable for study of smaller Foraminifera.

FIG. 1


NORTHWEST ECUADOR
COLOMBIA
PACIFIC OCEAN
1°N
80° W
Kms.
Borbón
Punta Ostiones
Punta Gorda
ESMERALDAS
Punta Galera
Galera
Timbre
Esmeraldas
Quinindé
Río Mataje
Río Verde
Río Papa
Río Viche
Río Guayllabamba
Río Hoja Blanca
Río Onzole
Río Cayapas
Río Santiago
Río Mataje
Río Tonsupa
Río Cónega
Río Chevele
Río Cadiva
Río Camarones
Río Mata
Río Papa
Río Ostiones
Río Cayapas
Río Esmeraldas

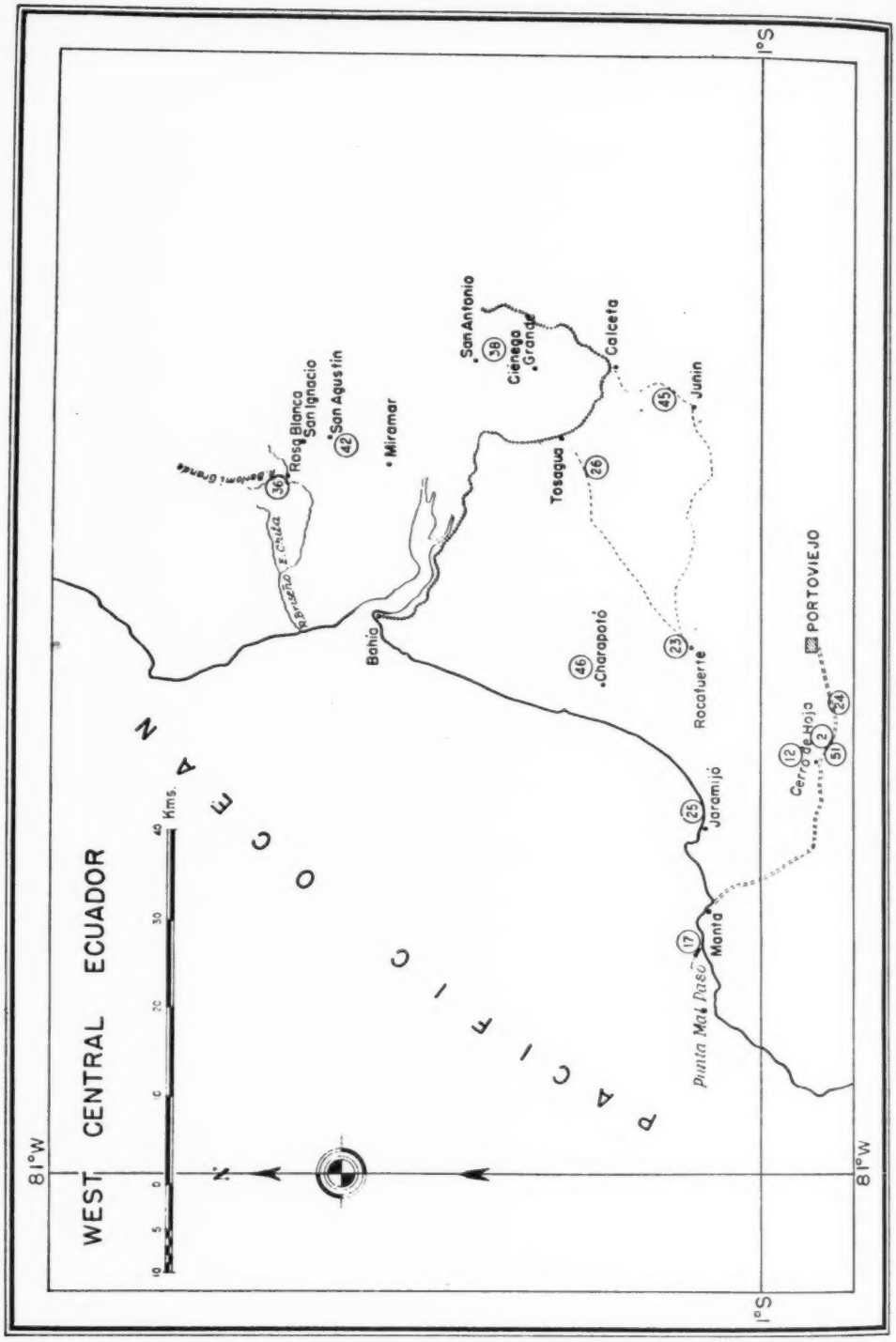


FIG. 3—Geographic positions of type localities of zonal units in west central Ecuador.

81°W

FIG. 3—Geographic positions of type localities of zonal units in west central Ecuador.

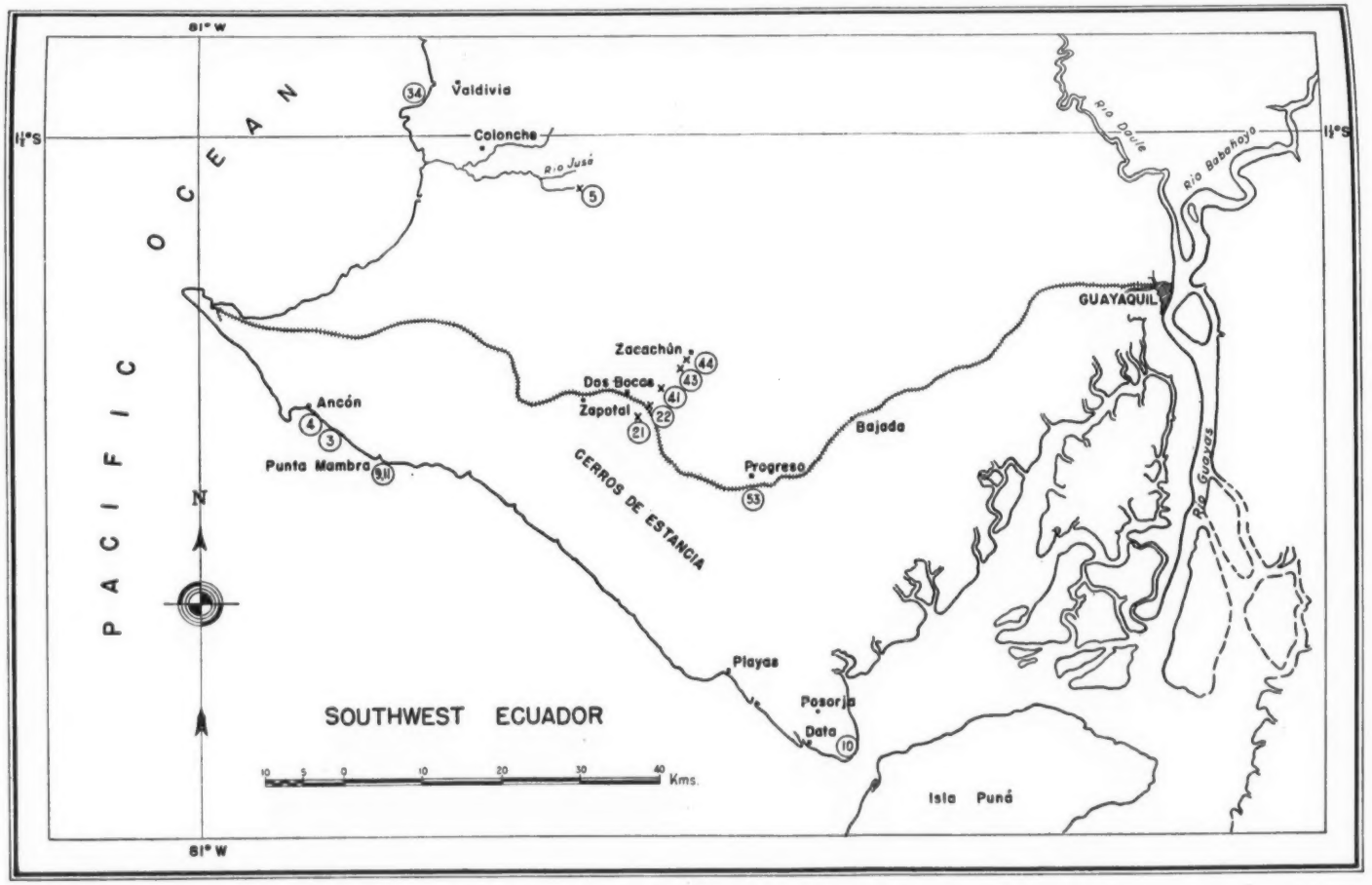


FIG. 4—Geographic positions of type localities of zonal units in southwest Ecuador.

terial occurs in shaly pockets. This is the only locality where loose specimens of smaller Foraminifera have been collected from this formation.

Coordinates.—N. 338 km., E. 47.5 km.

UNIT 2

Age.—Upper Cretaceous.
Formation.—Not named.
Facies.—Neritic.
Area.—Central.
Locality.—A quarry in white tuffaceous shale (below the San Mateo formation) on the hillside north of the Manta-Portoviejo road between the 22 km. and 23 km. posts, 14 km. due east of Portoviejo. Most samples are barren, but a few have yielded a distinctive foraminiferal fauna. (The *Globorotalia*-rich fauna known only at this place was formerly considered to be lower Eocene, but new evidence indicates that it is Upper Cretaceous and, therefore, it is not listed in this paper.)
Coordinates.—N. 125 km., W. 76 km.

UNIT 3

Age.—Upper middle Eocene.
Formation.—Socorro.
Facies.—Sublittoral.
Area.—South.
Locality.—Shale interbeds in sandstones between Ancon and Punta Mambra.
Coordinates.—S. 15.8 km., W. 107.6 km.

UNIT 4

Age.—Upper middle Eocene.
Formation.—Clay pebble beds.
Facies.—Reefal.
Area.—South.
Locality.—Sea cliffs at Ancon.
Coordinates.—S. 15.5 km., W. 108.3 km.

UNIT 5[2]

Age.—Upper Eocene.
Formation.—Jusá.
Facies.—Neritic.
Area.—South.
Locality.—Between the two main tributaries of Rio Jusá, 14 km. to 15 km. E.S.E. of Colonche. In certain wells this unit overlies sandstones containing molluscs similar to those occurring at Zapotal and Posorja.
Coordinates.—N. 13.5 km., W. 75 km.

UNIT 5a[2]

Age.—Upper Eocene.
Formation.—Seca.
Facies.—Neritic.
Area.—South.
Locality.—Just east of the type localities of units 9 and 11, in the sea cliffs at Punta Mambra.
Coordinates.—S. 22 km., W. 98.5 km.

UNIT 6

Age.—Upper Eocene.
Formation.—San Mateo.
Facies.—Neritic.
Area.—Central.
Locality.—Subsurface cores from a well near Manta, overlying tuffaceous shales of unit 12. There are no surface outcrops of this unit, which is covered by the Pleistocene Tablazo formation.

UNIT 7

Age.—Upper Eocene.
Formation.—Zapallo.
Facies.—Neritic.
Area.—North.
Locality.—On Rio Zapallo Grande, a major tributary which joins Rio Cayapas just south of Telembi, eastward from the unconformable Eocene-Oligocene contact at a point 9 km. E.S.E. of Telembi.
Coordinates.—N. 328 km., E. 117 km.

UNIT 8

Age.—Upper Eocene.
Formation.—Subsurface shales in Zapotal group.
Facies.—Sublittoral.
Area.—South.
Locality.—No satisfactory surface samples are available. Fauna is from cores from wells drilled east of the Cerros de Estancia. This unit consistently overlies subsurface sandstones containing molluscs similar to

[2] The microfaunas of the neritic facies of the Seca and Jusá formations (units 5 and 5a) are practically identical, and in the systematic part of this paper only the Jusá Foraminifera are described and figured, because of their better preservation. The Punta Mambra outcrops may be regarded as a subsidiary type locality of the upper Eocene neritic facies, being more readily accessible than the type outcrops of the Jusá but not providing such excellently preserved foraminiferal faunas.

those in the surface sandstones at Zapotal and Posorja.

UNIT 9

Age.—Upper Eocene.
Formation.—Seca.
Facies.—Reefal.
Area.—South.
Locality.—Sea cliffs west of Punta Mambra on the south coast. Most of the shales here represent a radiolarian facies (unit 11), but some layers are orbitoidal.
Coordinates.—S. 20.9 km., W. 101 km. to 102 km.

UNIT 10

Age.—Upper Eocene.
Formation.—"Data beds."
Facies.—Brackish.
Area.—South.
Locality.—This unit is exposed around Data at the southwest tip of the Guayaquil Estuary, but for study purposes correlated core samples have been used.

UNIT 11

Age.—Upper Eocene.
Formation.—Seca.
Facies.—Radiolarian.
Area.—South.
Locality.—Shale exposures in the sea cliffs west of Punta Mambra on the south coast, where some layers are orbitoidal (unit 9). Shales interbedded with and overlying the Ancon Point sandstones are lithologically and faunally identical.
Coordinates.—S. 20.9 km., W. 101 km. to 102 km.

UNIT 12

Age.—Upper Eocene.
Formation.—San Mateo.
Facies.—Radiolarian.
Area.—Central.
Locality.—On trails across the Cerro de Hoja, one running northward through locality 2, the other 2 km. farther west, leaving the Manta-Portoviejo road at Las Palmas, running east of north for 1 km., then swinging east to join the other. Various outcrops of light colored tuffaceous shale overlying white tuffs as at locality 2.
Coordinates.—N. 125.5 km., W. 76.5 km.

UNIT 13

Age.—Upper Eocene.
Formation.—Zapallo.
Facies.—Radiolarian.
Area.—North.
Locality.—Rio Verde area, on Estero Pollo (see unit 1) and the nearby Estero Pedernales; tuffaceous shales overlying San Eduardo limestone.
Coordinates.—N. 338 km., E. 47.5 km.

UNIT 14

Age.—Basal Oligocene.
Formation.—Playa Rica shale.
Facies.—Neritic.
Area.—North.
Locality.—On Estero Iguanero, a tributary of Rio Zapallo Grande, down dip from the junction with Estero Martin and up dip along the latter for 500 meters from the fork.
Coordinates.—N. 331 km., E. 113 km.

UNIT 15

Age.—Lower Oligocene.
Formation.—Playa Rica shale.
Facies.—Neritic.
Area.—North.
Locality.—Up dip for 500 meters from locality 14 on Esteros Iguanero and Martin. Identical material can be collected on any of the streams and rivers from Playa Rica to Telembi. Typically it is interbedded with orbitoidal gritty sands (unit 18).
Coordinates.—N. 332 km., E. 113 km.

UNIT 16

Age.—Top lower to lower middle Oligocene.
Formation.—Playa Rica shale.
Facies.—Neritic.
Area.—North.
Locality.—On Rio Pambil, a tributary to the Onzole above Santo Domingo, upstream from the base of the Angostura sands to a point 4 km. to the south. Lithologically similar to unit 15, but above the highest interbeds of orbitoidal sand.

UNIT 17

Age.—Lower Oligocene.
Formation.—San Mateo.
Facies.—Reefal.

Area.—Central.

Locality.—Punta Mal Paso on the coast, 4.5 km. west of Manta.

Coordinates.—N. 137.5 km., W. 97.5 km.

UNIT 18

Age.—Lower Oligocene.

Formation.—Playa Rica sands.

Facies.—Reefal.

Area.—North.

Locality.—Scattered outcrops of orbitoidal grit, interbedded with the shales of units 14 and 15, on Rios Cayapas and Zapallo Grande within 5 km. southward from Telembi.

Coordinates.—N. 330 km., E. 108 km.

UNIT 19

Age.—Lower Oligocene.

Formation.—Subsurface lignitic shales at top of Zapotal group.

Facies.—Brackish.

Area.—South.

Locality.—No satisfactory surface exposures are known, but in wells drilled east of the Cerros de Estancia this unit occurs consistently above shallow water marine beds of unit 8.

UNIT 20

Age.—Mid-middle Oligocene.

Formation.—Chumundé.

Facies.—Radiolarian.

Area.—North.

Locality.—On Rio Ostiones, up the main stream from 1 km. below its confluence with Rio Pepé. The entire section, except for the overlying Angostura and Viche sediments,

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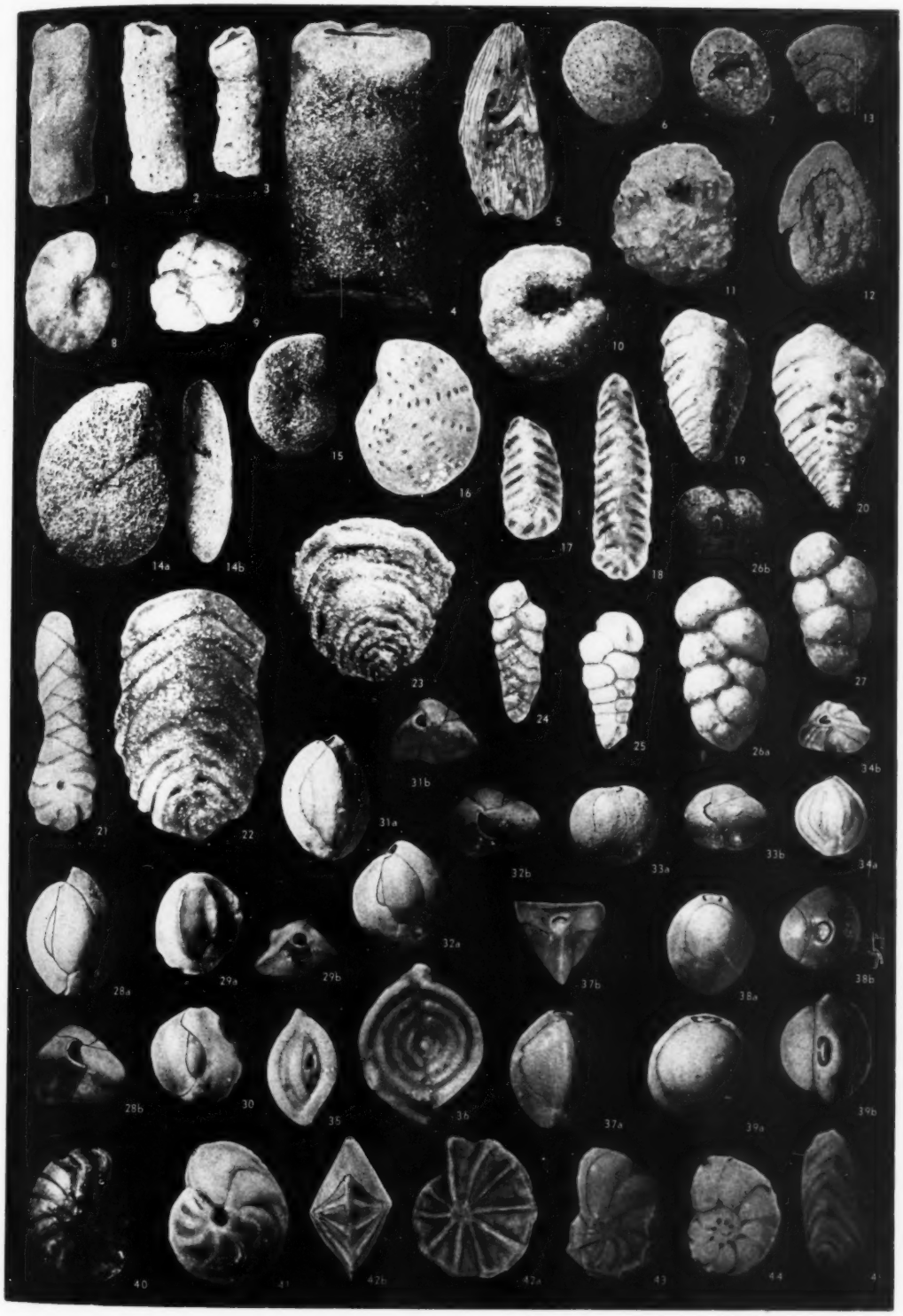
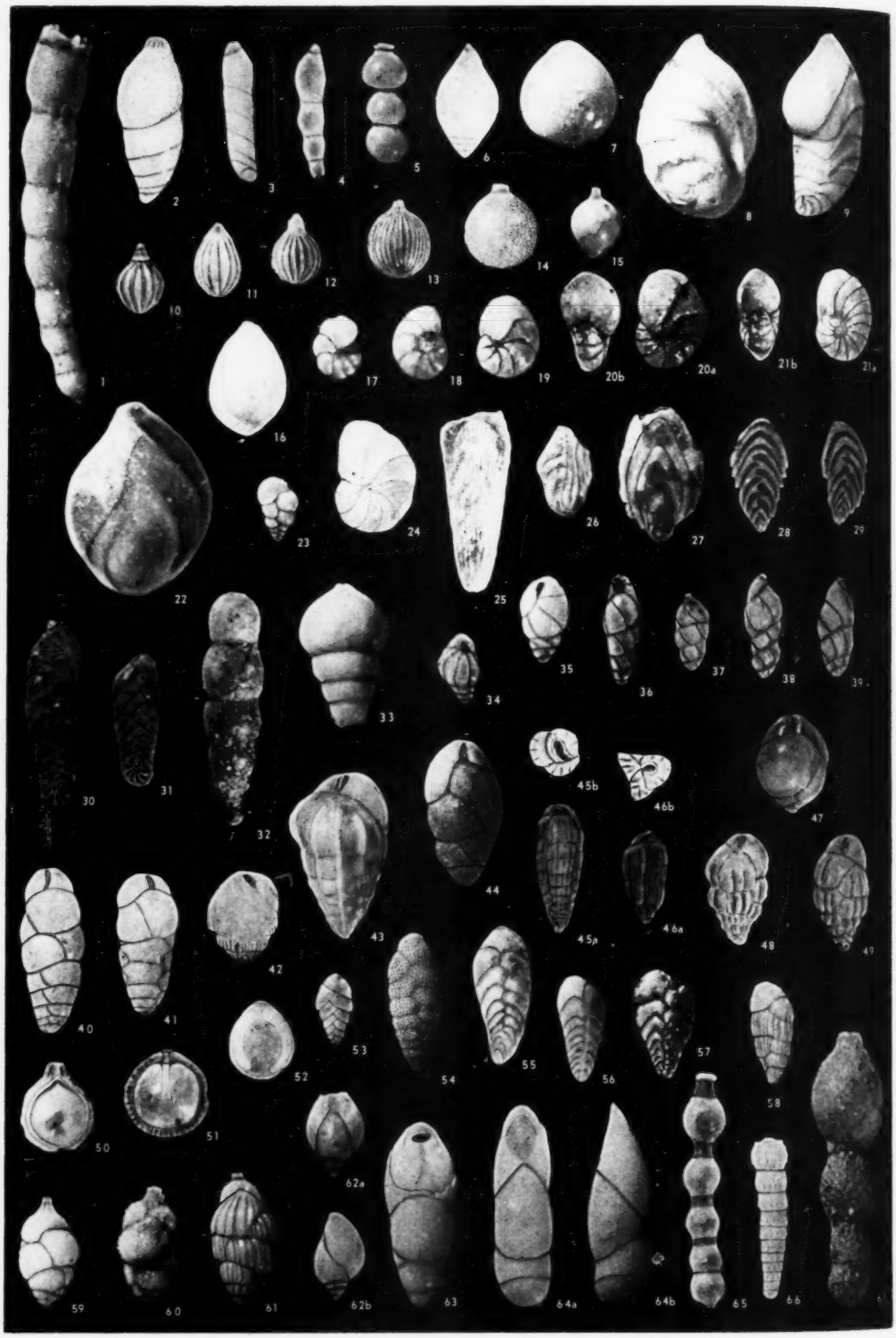
EXPLANATION OF PLATE 25

FIG. *1*—*Rhabdammina eocenica* Cushman & Hanna. ×13. (p. 142)
2, 3—*Rhabdammina samanica* Berry. ×25. (p. 142)
4—*Bathysiphon eocenica* Cushman & Hanna. ×13. (p. 142)
5—*Technitella archaeonitida* Stainforth & Stevenson. ×35. (p. 142)
6, 7—*Psammosphaera eocenica* Cushman & Stainforth, n. sp. ×25. *6*, Holotype; *7*, paratype, with broken wall, showing interior. (p. 142)
8—*Haplophragmoides carinatum* Cushman & Renz. ×35. (p. 143)
9—*Haplophragmoides* cf. *hetha* Berry. ×35. (p. 143)
10, 11—*Haplophragmoides* sp. *10*, ×35. *11*, ×25. (p. 143)
12, 13—*Ammodiscus* cf. *incertus* (d'Orbigny). ×35. *12*, Deformed specimen; *13*, fragment. (p. 143)
14–16—*Cyclammina* cf. *pacifica* Beck. *14, 15*, ×13. *14a*, Side view; *b*, peripheral view. *16*, ×25. Photographed in glycerin. (p. 143)
17, 18—*Spiroplectammina eocenica* (Cushman & Barksdale). ×35. (p. 143)
19, 20—*Spiroplectammina nuttalli* Lalicker. ×25. (p. 143)
21—*Spiroplectammina* sp. ×35. (p. 144)
22—*Vulvulina chirana* Cushman & Stone. ×25. (p. 144)
23—*Ammospirata mexicana* (Cushman). ×35. (p. 144)
24, 25—*Karreriella?* cf. *contorta* Beck. ×35. (p. 144)
26, 27—*Plectina nuttalli* Cushman & Stainforth, n. sp. ×25. *26*, Holotype; *a*, front view; *b*, apertural view; 27, paratype. (p. 144)
28—*Quinqueloculina* cf. *seminula* (Linné). ×25. *a*, Side view; *b;* apertural view. (p. 144)
29–31—*Quinqueloculina* cf. *lamarckiana* d'Orbigny. ×25. *29a, 30a, 31a*. Side views; *29b, 30b, 31b*, apertural views. (p. 144)
32—*Quinqueloculina orbiculata* Cushman & Stainforth, n. sp. ×25. *a*, Side view; *b*, apertural view. (p. 145)
33—*Triloculina* cf. *globosa* (Hanna & Hanna). ×13. *a*, Side view; *b*, apertural view. (p. 145)
34—*Quinqueloculina* aff. *contorta* d'Orbigny. ×35. *a*, Side view; *b*, apertural view. (p. 145)
35—*Sigmoilina tenuis* (Czjzek). ×35. (p. 145)
36—*Spiroloculina jarvisi* Cushman & Todd. ×35. (p. 145)
37—*Triloculina tricarinata* d'Orbigny. ×35. *a*, Side view; *b*, apertural view. (p. 145)
38—*Pyrgo danvillensis* Howe & Wallace. ×25. *a*, Front view; *b*, apertural view. (p. 145)
39—*Pyrgo pseudoinornata* Cushman & Stainforth, n. sp. ×25. *a*, Front view; *b*, apertural view. (p. 145)
40—*Robulus coaledensis* Detling. ×35. (p. 146)
41—*Robulus chiranus* Cushman & Stone. ×35. (p. 146)
42—*Robulus insuetus* Cushman & Stainforth. ×25. *a*, Side view; *b*, peripheral view. (p. 146)
43—*Planularia* cf. *clara* Cushman & Jarvis. ×35. (p. 146)
44—*Planularia* sp. A. ×35. (p. 147)
45—*Planularia* sp. B. ×35. (p. 147)



Cushman and Stainforth, Ecuador Eocene Foraminifera



Cushman and Stainforth, Ecuador Eocene Foraminifera

Explanation of Plate 26

FIG. *1*—*Dentalina* ? cf. *mucronata* Neugeboren. ×35. (p. 147)
2—*Marginulina* cf. *eximia* Neugeboren. ×35. (p. 147)
3—*Marginulina* cf. *attenuata* Neugeboren. ×35. (p. 147)
4—*Dentalina* cf. *communis* d'Orbigny. ×35. (p. 147)
5—*Nodosaria chirana* Cushman & Stone. ×35. (p. 147)
6—*Pseudoglandulina laevigata* (d'Orbigny). ×35. (p. 147)
7—*Pseudoglandulina* cf. *turbinata* Detling. ×35. (p. 147)
8—*Vaginulina saundersi* (Hanna & Hanna). ×25. (p. 147)
9—*Saracenaria hantkeni* Cushman. ×35. (p. 147)
10—*Lagena aculicosta* Reuss. ×35. (p. 148)
11—*Lagena raricosta* (d'Orbigny). ×35. (p. 148)
12—*Lagena* cf. *striata* Williamson. ×35. (p. 148)
13—*Lagena* cf. *gracilicosta* Reuss. ×35. (p. 148)
14—*Lagena* cf. *laevis* (Montagu). ×35. (p. 148)
15—*Lagena* sp. ×35. (p. 148)
16—*Globulina* cf. *minuta* (Roemer). ×35. (p. 148)
17—*Nonion danvillense* Howe & Wallace. ×35. (p. 149)
18—*Nonion planatum* Cushman & Thomas. ×35. (p. 149)
19, 20—*Nonion ecuadoranum* Cushman & Stainforth, n. sp. ×35. 19, Paratype; 20, holotype; *a*, side view; *b*, peripheral view. (p. 149)
21, 24—*Nonionella hantkeni* (Cushman & Applin), vars. ×35. 21*a*, Dorsal view; *b*, peripheral view. (p. 149)
22—*Sigmomorphina trinitatensis* Cushman & Ozawa. ×25. (p. 148)
23—*Gümbelina venezuelana* Nuttall. ×35. (p. 149)
25—*Plectofrondicularia cookei* Cushman. ×35. (p. 150)
26—*Plectofrondicularia packardi* var. *multilineata* Cushman & Simonson. ×35. (p. 150)
27—*Plectofrondicularia vaughani* Cushman. ×35. (p. 150)
28, 29—*Plectofrondicularia dentifera* Cushman & Stainforth. ×33. *28*, Paratype; *29*, holotype. (p. 150)
30, 31—*Bolivinopsis pulchella* Cushman & Stainforth. ×33. *30*, Paratype; *31*, holotype. (p. 149)
32—*Nodogenerina* cf. *rohri* Cushman & Stainforth. ×35. (p. 150)
33—*Nodogenerina* sp. ×35. (p. 151)
34—*Buliminella peruviana* Cushman & Stone. ×35. (p. 151)
35—*Buliminella peruviana* var. *obesa* Cushman & Stainforth, n. var. ×35. (p. 151)
36—*Buliminella chirana* Cushman & Stone. ×35. (p. 151)
37-39—*Buliminellita mirifica* Cushman & Stainforth. ×33. *37*, *38*, Paratypes; *39*, holotype. (p. 151)
40, 41—*Bulimina affectata* Cushman & Stainforth, n. sp. ×35. *40*, Holotype; *41*, paratype. (p. 154)
42—*Bulimina stalacta* Cushman & Parker. ×35. (p. 151)
43—*Bulimina jacksonensis* Cushman. ×35. (p. 151)
44—*Bulimina ovata* d'Orbigny. ×25. (p. 151)
45—*Bulimina lineata* Cushman & Stainforth. ×33. *a*, Front view; *b*, apertural view. (p. 153)
46—*Bulimina acutangularis* Cushman & Stainforth. ×33. *a*, Front view; *b*, apertural view. (p. 154)
47—*Bulimina decurtata* Cushman & Stainforth. ×25. (p. 153)
48, 49—*Bulimina secaensis* Cushman & Stainforth. ×25. *48*, Paratype; *49*, holotype. (p. 152)
50—*Entosolenia orbignyana* Seguenza. ×35. (p. 154)
51—*Entosolenia* cf. *marginata* (Walker & Boys). ×35. (p. 154)
52—*Entosolenia* cf. *lucida* Williamson. ×35. (p. 154)
53—*Bolivina basisenta* Cushman & Stone. ×35. (p. 155)
54—*Bolivina maculata* Cushman & Stone. ×35. (p. 155)
55, 56—*Bolivina jacksonensis* Cushman & Applin. ×35. (p. 155)
57—*Bolivina alazanensis* Cushman. ×35. (p. 155)
58—*Loxostomum dalli* (Cushman). ×35. (p. 155)
59—*Uvigerina mantaensis* Cushman & Edwards. ×35. (p. 155)
60—*Uvigerina chirana* Cushman & Stone. ×35. (p. 155)
61—*Uvigerina yazooensis* Cushman. ×35. (p. 155)
62—*Pleurostomella obesa* Cushman & Bermudez. ×35. *a*, Front view; *b*, side view. (p. 156)
63—*Pleurostomella* cf. *acuta* Hantken. ×35. (p. 156)
64—*Pleurostomella ecuadorana* Cushman & Stainforth, n. sp. ×35. *a*, Front view; *b*, side view. (p. 156)
65—*Ellipsonodosaria nuttalli* var. *gracillima* Cushman & Jarvis. ×35. (p. 156)
66—*Ellipsonodosaria curvatura* Cushman. ×35. (p. 156)
67—*Ellipsonodosaria decurta* Bermudez. ×35. (p. 156)

is exposed along the right-hand branch of the highest fork.

Coordinates.—N. 345 km., E. 65 km.

UNIT 21

Age.—Late middle to early upper Oligocene.

Formation.—Dos Bocas.

Facies.—Neritic.

Area.—South.

Locality.—The type section of the Oligo-Miocene Dos Bocas group or formation extends southwest from Zacachun through the nearest point of the railway for some 12 km. Limits of the zonal units considered here are:

Unit 44: from 0.4 km. to 1.0 km. from Zacachun.

Unit 43: from 1.0 km. to 3.0 km. from Zacachun.

Unit 41: between 3.0 km. from Zacachun and 0.5 km. northeast of the railway.

Unit 22: half a kilometer on either side of the railway.

Unit 21: from 9 km. to 12 km. southwest of Zacachun between the railway and the old rocks on the flank of the Cerros de Estancia.

For study purposes the surface material, mostly badly weathered, has been supplemented by core samples from shallow holes along the type section.

UNIT 22

Age.—Upper Oligocene.

Formation.—Dos Bocas.

Facies.—Neritic.

Area.—South.

Locality.—See under unit 21.

UNIT 23

Age.—Top middle Oligocene.

Formation.—Tosagua.

Facies.—Neritic.

Area.—Central.

Locality.—Scattered surface outcrops within 5 km. of Rocafuerte.

Coordinates.—N. 140 km., W. 63 km.

UNIT 24

Age.—Upper Oligocene.

Formation.—Tosagua.

Facies.—Neritic.

Area.—Central.

Locality.—Road cuts on the Manta-Portoviejo road between 6 km. and 10.5 km. west of Portoviejo (road distance).

Coordinates.—N. 123 km., W. 72 km.

UNIT 25

Age.—Upper Oligocene.

Formation.—Tosagua.

Facies.—Neritic.

Area.—Central.

Locality.—In the sea cliffs of Jarmijo Bay, some 10 km. east of Manta. This is almost certainly the same locality referred to by Galloway and Morrey in their well known paper on the "Manta" fauna.

Coordinates.—N. 139 km., W. 83 km.

UNIT 26

Age.—Upper Oligocene.

Formation.—Tosagua.

Facies.—Neritic.

Area.—Central.

Locality.—Along the Tosagua-Rocafuerte road for 10 km. west of Tosagua, and in a 5-km. strip parallel and south of this road.

Coordinates.—N. 150 km., W. 45 km.

UNIT 27

Age.—Upper middle Oligocene.

Formation.—Viche.

Facies.—Neritic.

Area.—North.

Locality.—Parallel sections on Rio Verde from 7.5 km. to 9 km. in a straight line from the coast, and on Rio Maté from 7 km. to 11.5 km. from the coast.

Coordinates.—N. 352 km., E. 53 km.

UNIT 28

Age.—Top middle to basal upper Oligocene.

Formation.—Viche.

Facies.—Neritic.

Area.—North.

Locality.—Shale outcrops 2 km. to 3 km. below the hamlet of Timbre, on the main Rio Esmeraldas.

Coordinates.—N. 337 km., E. 31 km.

UNIT 29

Age.—Upper Oligocene.

Formation.—Viche.

Facies.—Neritic.

Area.—North.

Locality.—On Rio Viche, from its junc-

tion with the Esmeraldas 10 km. upstream (straight line measure).

Coordinates.—N. 309 km., E. 35 km.

UNIT 30

Age.—Upper Oligocene.

Formation.—Viche.

Facies.—Neritic.

Area.—North.

Locality.—Beds conformably overlying unit 27, along parallel sections on Rio Verde and Rio Maté upstream from their mouths for 6 km. in a straight line from the coast.

Coordinates.—N. 358 km., E. 57 km.

UNIT 31

Age.—Upper middle to early upper Oligocene.

Formation.—Angostura.

Facies.—Sublittoral.

Area.—North.

Locality.—Above Cupa limestone on Estero Piedra Blanca, a tributary of the Hoja Blanca, and on Rio Pambil 5 km. due north. This area is some 28 km. southwest of Telembi.

Coordinates.—N. 312 km., E. 81 km.

UNIT 32

Age.—Upper Oligocene.

Formation.—Angostura.

Facies.—Sublittoral.

Area.—North.

Locality.—On Rio Pambil, unconformable on unit 16, from 2.0 km. to 3.5 km. south of its junction with the Onzole.

Coordinates.—N. 325 km., E. 90 km.

UNIT 33

Age.—Top Oligocene.

Formation.—Angostura.

Facies.—Sublittoral.

Area.—North.

Locality.—Scattered outcrops of foraminiferal silt within the basal Angostura sands along Estero Bureo and between this stream and Telembi, 1.5 km. to the east.

Coordinates.—N. 332 km., E. 105 km.

UNIT 34

Age.—Late middle to early upper Oligocene.

Formation.—San Pedro sand.

Facies.—Reefal.

Area.—South.

Locality.—A prominent bluff overlooking the village of San Pedro near Valdivia, on the coast. For washed residue studies the best samples may be collected from the top at the north end.

Coordinates.—N. 27 km., W. 93 km.

UNIT 35

Age.—Late middle to early upper Oligocene.

Formation.—Cupa limestone.

Facies.—Reefal.

Area.—North.

Locality.—On a trail leading south from Rio Pambil, leaving the river 1.5 km. west of a prominent right angle bend which is 2.5 km. south of the type locality of unit 16. The outcrop is 2.5 km. south of Rio Pambil, 12.0 km., S. 7° W. from the Onzole-Pambil confluence. The samples are good for study purposes, but stratigraphic control is poor because of landslip conditions. Stratigraphic relations are clearer on Estero Piedra Blanca, 9 km. to the west and just south of locality 31, but the rock there can be studied only in thin section.

Coordinates.—N. 315 km., E. 87.5 km.

UNIT 36

Age.—Upper Oligocene.

Formation.—Tosagua.

Facies.—Radiolarian.

Area.—Central.

Locality.—On Rio Barlomi Grande, upstream and north from the fork near Rosa Blanca, 20 km. northeast from Bahia.

Coordinates.—N. 188 km., W. 45 km.

UNIT 37

Age.—Upper Oligocene.

Formation.—Viche.

Facies.—Radiolarian.

Area.—North.

Locality.—Near the head of Rio Viche, from 25 km. to 31 km. southwest of its junction with Rio Esmeraldas.

Coordinates.—N. 295 km., E. 18 km.

UNIT 38

Age.—Top Oligocene.

Formation.—Tosagua.

Facies.—Neritic.

Area.—Central.

Locality.—A strip of country 2 km. to

3 km. wide, extending north-south and lying just east of a line from San Antonio to Cienega Grande, a little east of Tosagua.

Coordinates.—N. 160 km., W. 30 km.

UNIT 39

Age.—Top Oligocene.
Formation.—Viche.
Facies.—Neritic.
Area.—North.
Locality.—On the upper Rio Verde, midway between the Verde-Merive and Verde-Papa confluences. (A little to the west, outcrops less accessible, but better known stratigraphically, occur at the heads of several steep tributaries of the Rio Majua.)
Coordinates.—N. 322 km., E. 54 km.

UNIT 40

Age.—Top Oligocene.
Formation.—Viche.
Facies.—Neritic.
Area.—North.
Locality.—On Rio Verde, a little to the north of the outcrops of unit 39. The outcrop area is enclosed in a broad southwest bend of the river, 4.5 km. south-southwest of the Verde-Merive confluence.
Coordinates.—N. 322.5 km., E. 53 km.

UNIT 41

Age.—Top Oligocene.
Formation.—Dos Bocas.
Facies.—Sublittoral.
Area.—South.
Locality.—See under unit 21.

UNIT 42

Age.—Top Oligocene.
Formation.—San Agustin.
Facies.—Sublittoral.
Area.—Central.
Locality.—Foraminiferal shales interbedded with sandstones exposed in the area of Hacienda San Agustin, Hacienda San Ignacio and Miramar, some 20 km. to 30 km. north of Tosagua.
Coordinates.—N. 180 km., W. 40 km.

UNIT 43

Age.—Lower Miocene.
Formation.—Dos Bocas.
Facies.—Sublittoral.
Area.—South.
Locality.—See under unit 21.

UNIT 44

Age.—Lower Miocene.
Formation.—Dos Bocas.
Facies.—Sublittoral.
Area.—South.
Locality.—See under unit 21.

UNIT 45

Age.—Lower Miocene.
Formation.—Intermediate between San Agustin and Charapotó.
Facies.—Sublittoral.
Area.—Central.
Locality.—Southeast of Tosagua, along the Calceta-Junin-Rocafuerte road for 20 km. (road distance) south and west of Calceta, and in the 5-km. strip bordering the road to the north and west. This unit overlies unit 26.
Coordinates.—N. 140 km., W. 40 km.

UNIT 46

Age.—Lower Miocene.
Formation.—Charapotó.
Facies.—Sublittoral.
Area.—Central.
Locality.—Scattered outcrops within 6 km. of Charapotó.
Coordinates.—N. 150 km., W. 65 km.

UNIT 47

Age.—Lower to early middle Miocene.
Formation.—Charapotó-Onzole.
Facies.—Sublittoral.
Area.—Central-north.
Locality.—Seven to 8 km. northeast of Daule on the west coast, outcrops along Rio Agua Clara, a tributary of the Daule, northwest to the Estero Complacidero junction and southward along the latter stream.
Coordinates.—N. 289 km., W. 11 km.

UNIT 48

Age.—Lower Miocene.
Formation.—Angostura.
Facies.—Sublittoral.
Area.—North.
Locality.—Outcrops extending along the strike, slightly offset by cross faults, immediately above the massive Angostura sands as exposed on Rio Onzole, Rio Camarones, and lesser streams just south of a line

through Santo Domingo on the Onzole and Telembi on the Cayapas.

Coordinates.—N. 328 km., E. 95 km.

UNIT 49

Age.—Lower Miocene.
Formation.—Onzole.
Facies.—Sublittoral.
Area.—North.
Locality.—On Rio Onzole from 0.5 km. south to 3.0 km. north of Santo Domingo, and along the strike of these outcrops for some 15 km. westward.
Coordinates.—N. 332 km., E. 90 km.

UNIT 50

Age.—Late lower to early middle Miocene.
Formation.—Onzole.
Facies.—Sublittoral.
Area.—North.
Locality.—Conformably overlying unit 49 in an east-west trending belt. Exposures sampled on Rio Cayapas below Camarones. Rio Onzole from 3.5 km. to 5.0 km. north of Santo Domingo, the headwaters of Estero Tangaré, and lesser streams.
Coordinates.—N. 335 km., E. 92 km.

UNIT 51

Age.—Lower Miocene.
Formation.—Charapotó.
Facies.—Radiolarian.
Area.—Central.
Locality.—Cuts on the Manta-Portoviejo road between 11 km. and 15 km. (road distance) west of Portoviejo.
Coordinates.—N. 124 km., W. 75 km.

UNIT 52

Age.—Lower Miocene.
Formation.—Onzole.
Facies.—Radiolarian.
Area.—North.
Locality.—Near the northern tip of Punta Galera, along the coast for 8 km. on either side of the hamlet of Galera.
Coordinates.—N. 333 km., W. 17 km.

UNIT 53

Age.—Middle Miocene.
Formation.—Bajada (after Sheppard).
Facies.—Brackish.
Area.—South.
Locality.—Along and near the Guayaquil-Playas road, south of Progreso between the 75 and 77 km. posts, 2 km. to 3 km. south of the railway intersection.
Coordinates.—S. 28 km., W. 55 km.

UNIT 54

Age.—Late lower and early middle Miocene.
Formation.—Onzole.
Facies.—Brackish.
Area.—North.
Locality.—Lenticular interbeds along the strike west of the type outcrops of unit 50, which swing to the north at the head of Estero Tangaré. Exposures are known in Rio Culebra and due north, around the heads of Rio, Lagarto and Lagartillo. The general area is 25 km. to 30 km. northwest of Santo Domingo on the Onzole and 10 km. south-southeast of Punta Ostiones.
Coordinates.—N. 335 km., E. 75 km.

UNIT 55

Age.—Upper middle to upper Miocene.
Formation.—Borbon.
Facies.—Brackish to sublittoral.
Area.—North.
Locality.—Scattered foraminiferal outcrops in the generally barren silts exposed in the angle between the Cayapas above Borbon, the Onzole up to Anchayacu, and Estero Anchayacu.
Coordinates.—N. 357 km., E. 90 km.

UNIT 56

Age.—Upper middle Miocene.
Formation.—Borbon.
Facies.—Neritic.
Area.—North.
Locality.—On Rio Tonsupa from 1 km. above its mouth to 3.5 km. farther east.
Coordinates.—N. 340 km., E. 11 km.

UNIT 57

Age.—Late middle to early upper Miocene.
Formation.—Borbon.
Facies.—Neritic.
Area.—Central and north.
Locality.—On Rio Camarones, 8 km. east of the Esmeraldas, for 4 km. above its mouth. Similar strata are exposed intermittently in the sea cliffs south and north of Bahia.
Coordinates.—N. 350 km., E. 36 km.

UNIT 58

Age.—Upper Miocene.
Formation.—Borbon ("Punta Gorda").
Facies.—Neritic.
Area.—North.
Locality.—On the north coast, from the mouth of Rio Esmeraldas westward to Rio Culiva and for 2 km. up that stream.
Coordinates.—N. 349 km., E. 18 km.

UNIT 59

Age.—Topmost Miocene.
Formation.—Borbon ("Punta Gorda").
Facies.—Neritic.
Area.—North.
Locality.—On the north coast, west of the outcrops of unit 58, between Rio Chevele and Estero Ciénago (Campo Allegre) and also inland along Rios Culiva and Chevele.
Coordinates.—N. 345 km., E. 13 km.

SYSTEMATIC DESCRIPTIONS

Family ASTRORHIZIDAE
Genus RHABDAMMINA Sars, 1869
RHABDAMMINA EOCENICA Cushman & Hanna
Plate 25, figure 1

Rhabdammina eocenica CUSHMAN & HANNA, 1927, California Acad. Sci. Proc., ser. 4, vol. 16, p. 209, pl. 13, fig. 1.

The types of this species are from the Eocene, 7 miles north of Coalinga, California. A number of specimens in the Ecuador Eocene are very similar. They are from localities 3, 6 and 9.

RHABDAMMINA SAMANICA Berry
Plate 25, figures 2, 3

Rhabdammina samanica BERRY, 1928, Eclogae geol. Helvetiae, vol. 21, p. 392, text-fig. 21.

Only an outline figure is given of the type, which is from the Eocene Lobitos shales of Peru. A number of specimens, much smaller than the preceding species, but similar to the type of this one, occur at localities 3, 7 and 9. These may belong to the preceding species or be a variety of it, but more nearly complete specimens are needed to determine their relationship.

Family RHIZAMMINIDAE
Genus BATHYSIPHON Sars, 1872
BATHYSIPHON EOCENICA Cushman & Hanna
Plate 25, figure 4

Bathysiphon eocenica CUSHMAN & HANNA, 1927, California Acad. Sci. Proc., ser. 4, vol. 16, p. 210, pl. 13, figs. 2, 3; CUSHMAN & MCMASTERS, 1936, Jour. Paleontology, vol. 10, p. 508, pl. 74, fig. 1; CUSHMAN & SIEGFUS, 1942, San Diego Soc. Nat. Hist. Trans., vol. 9, p. 400, pl. 15, fig. 1; CUSHMAN & SIMONSON, 1944, Jour. Paleontology, vol. 18, p. 193, pl. 30, fig. 1; CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 2, pl. 1, fig. 1.

This species has been recorded mostly from the Eocene of California and it has recently been reported from the Eocene Chira shale of Peru. The Ecuador specimens show a considerable range in size, some reaching 1.75 mm. in diameter. They occur at localities 6, 7 and 9.

Family SACCAMMINIDAE
Genus PSAMMOSPHAERA Schulze, 1875
PSAMMOSPHAERA EOCENICA
Cushman & Stainforth, n. sp.
Plate 25, figures 6, 7

Test subspherical, single chambered; wall thick, of rather coarse sand grains with considerable cement, strongly united, surface fairly smooth; no aperture visible. Diameter, 0.40–0.60 mm.

Holotype (Cushman Collection No. 64065) from the upper Eocene Seca shale exposures in sea cliffs west of Punta Mambra, Ecuador (locality 11). It also occurs at locality 12.

It differs from *P. fusca* Schulze in the much thicker wall and smoother exterior.

Genus TECHNITELLA Norman, 1878
TECHNITELLA ARCHAEONITIDA
Stainforth & Stevenson
Plate 25, figure 5

Technitella archaeonitida STAINFORTH & STEVENSON, 1946, Jour. Paleontology, vol. 20, p. 561, pl. 86, figs. 1–3.

This species was described from the lower Oligocene Playa Rica formation of Ecuador. Specimens also occur in considerable numbers at localities 3, 9 and 12.

Family AMMODISCIDAE
Genus AMMODISCUS Reuss, 1861
AMMODISCUS cf. INCERTUS (d'Orbigny)
Plate 25, figures 12, 13

Numerous incomplete specimens seem similar to those from the Eocene Chira shale of Peru (Cushman and Stone, 1947, p. 2, pl. 1, fig. 2). Their large coils resemble the figure of *A. coombsi* Beck (1943, p. 591, pl. 98, fig. 1) from the Eocene of Cowlitz River, Lewis County, Washington, but our specimens have more coils and no types of that species are available for comparison. Our specimens are not similar in size nor do they correspond to descriptions given by W. Berry for forms from the Eocene of Peru. Specimens are common at locality 6 and rare at localities 7 and 9.

Family LITUOLIDAE
Genus HAPLOPHRAGMOIDES Cushman, 1910
HAPLOPHRAGMOIDES CARINATUM
Cushman & Renz
Plate 25, figure 8

Haplophragmoides carinatum CUSHMAN & RENZ, 1941, Cushman Lab. Foram. Research Contr., vol. 17, p. 2, pl. 1, fig. 1; CUSHMAN & STAINFORTH, 1945, idem, Spec. Pub. 14, p. 15, pl. 1, fig. 18; RENZ, 1948, Geol. Soc. America Mem. 32, p. 141, pl. 1, fig. 4.

Rather rare specimens from localities 3, 7, 8 and 9 seem very close to this species, known from the Agua Salada formation of Venezuela and the Cipero formation of Trinidad.

HAPLOPHRAGMOIDES cf. HETHA Berry
Plate 25, figure 9

Haplophragmoides hetha BERRY, 1932, Eclogae geol. Helvetiae, vol. 25, p. 26, pl. 3, figs. 10–12.

Rare specimens from locality 9 seem to be related to this species, described from the upper Oligocene Heath formation of Peru.

HAPLOPHRAGMOIDES sp.
Plate 25, figures 10, 11

A few specimens from locality 6 have a rather deep umbilical area on both sides bnt are not well enough preserved to justify a specific identification.

Genus CYCLAMMINA Brady, 1876
CYCLAMMINA cf. PACIFICA Beck
Plate 25, figures 14–16

Cyclammina pacifica BECK, 1943, Jour. Paleontology, vol. 17, p. 591, pl. 98, figs. 2, 3.

Test comparatively large, strongly compressed, periphery slightly rounded, umbilical region not depressed; chambers numerous, 13 to 19 in the adult coil, increasing very gradually and evenly in size as added, not inflated; sutures not depressed, gently curved, fairly thick; wall thin, smooth, showing the internal structure slightly, especially when moistened; aperture a narrow, curved opening at base of apertural face of last formed chamber with supplementary, rounded openings in apertural face. Diameter up to 1.30 mm.; thickness, 0.50 mm.

Specimens resembling *Cyclammina pacifica* Beck, but differing in the larger number of chambers and the curved and not depressed sutures, occur commonly at locality 6, and less commonly at localities 3 and 7.

Family TEXTULARIIDAE
Genus SPIROPLECTAMMINA Cushman, 1927
SPIROPLECTAMMINA NUTTALLI Lalicker
Plate 25, figures 19, 20

Spiroplectammina nuttalli LALICKER, 1935, Cushman Lab. Foram. Research Contr., vol. 11, p. 43, pl. 6, figs. 3, 4.
Textularia aff. *pala* NUTTALL (not Czjzek), 1935, Jour. Paleontology, vol. 9, p. 123, pl. 14, fig. 4.

Specimens have been compared with the types of this species, described from the Eocene of Venezuela, and seem identical. The species is very common at locality 6.

SPIROPLECTAMMINA EOCENICA
(Cushman & Barksdale)
Plate 25, figures 17, 18

Spiroplectoides eocenica CUSHMAN & BARKSDALE, 1930, Stanford Univ. Contr. Dept. Geol., vol. 1, p. 66, pl. 12, fig. 5; CUSHMAN, 1934, Cushman Lab. Foram. Research Contr., vol. 10, p. 43, pl. 6, fig. 28.

An examination of the test of this species seems to show that it is finely arenaceous and probably should be placed in the genus *Spiroplectammina*. Specimens from locality 3 are abundant and, when compared with the types from the Eocene of California, seem to be the same.

SPIROPLECTAMMINA sp.
Plate 25, figure 21

A single specimen from locality 9 appears to have an arenaceous test and therefore to belong in this genus. It does not seem to belong to any described species.

Genus AMMOSPIRATA Cushman, 1933
AMMOSPIRATA MEXICANA (Cushman)
Plate 25, figure 23

Pavonina mexicana CUSHMAN, 1926, U. S. Nat. Mus. Proc., vol. 67, art. 25, p. 22, pl. 6, figs. 7–9.

Ammospirata mexicana CUSHMAN, 1933, Cushman Lab. Foram. Research Contr., vol. 9, p. 32, pl. 3, fig. 4; ——, 1933, idem, Spec. Pub. 5, pl. 7, fig. 16; PALMER & BERMUDEZ, 1936, Soc. cubana hist. nat. Mem., vol. 10, p. 240, pl. 13, figs. 7, 8; BERMUDEZ, 1937, idem, vol. 11, p. 338; CUSHMAN, 1940, Foraminifera, 3d. ed., pl. 11, fig. 3, key, pl. 7, fig. 16; RENZ, 1942, 8th American Sci. Cong. Proc., p. 548 (list); CUSHMAN, 1945, Cushman Lab. Foram. Research Contr., vol. 21, p. 49.

Several specimens from locality 8 have been compared with the types of this species and seem identical. The species has been recorded from the Oligocene and Eocene of the West Indian region and Mexico.

Genus VULVULINA d'Orbigny, 1826
VULVULINA CHIRANA Cushman & Stone
Plate 25, figure 22

Vulvulina chirana, CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 4, pl. 1, fig. 10.

Specimens from localities 6 and 7 seem to be identical with this species, recently described from the Eocene Chira shale of Peru.

Family VALVULINIDAE
Genus PLECTINA Marsson, 1878
PLECTINA NUTTALLI
Cushman & Stainforth, n. sp.
Plate 25, figures 26, 27

Plectina dalmatina NUTTALL (not Liebus), 1935, Jour. Paleontology, vol. 9, p. 123, pl. 14, fig. 8; KELLEY, 1943, Am. Assoc. Petroleum Geologists Bull., vol. 27, p. 11 (list).

Test about twice as long as broad, early portion with as many as five chambers to a whorl, later biserial but with the axis somewhat twisted, periphery rounded; chambers of the early portion obscure, later ones inflated, consisting usually of three pairs of rather uniform size in the adult; sutures of the early portion rather indistinct, in the adult distinct, strongly depressed; wall distinctly arenaceous, but rather smoothly finished; aperture in the adult rounded, in a slight depression of the apertural face and with a slightly thickened lip. Length, 1.00–1.20 mm.; breadth, 0.50–0.60 mm.

Holotype (Cushman Collection No. 63757) from the Eocene San Mateo formation, subsurface core material from a well near Manta, Ecuador (locality 6). It also occurs rarely at localities 7 and 12. The species is abundant at the type locality and is apparently the same as the form figured by Nuttall from the Eocene of Venezuela. It differs from *P. dalmatina* (Schubert) in the larger number of biserial chambers, longer test, and larger early portion.

Genus KARRERIELLA Cushman, 1933
KARRERIELLA? cf. CONTORTA Beck
Plate 25, figures 24, 25

Karreriella contorta BECK, 1943, Jour. Paleontology, vol. 17, p. 592, pl. 98, figs. 4, 5; CUSHMAN, 1947, Cushman Lab. Foram. Research Spec. Pub. 8A, p. 41, pl. 7, fig. 19.

A number of specimens from locality 6 have been compared with an autotype of this species, described from the Eocene of Cowlitz River, Lewis County, Washington, and are very similar in most characters. Our specimens reach only about half the size and do not have the terminal aperture, but a large opening running up into the apertural face. They may not be adult specimens.

Family MILIOLIDAE
Genus QUINQUELOCULINA d'Orbigny, 1826
QUINQUELOCULINA cf. SEMINULA (Linné)
Plate 25, figure 28

A few specimens from locality 6 seem very close to this widely recorded species.

QUINQUELOCULINA cf. LAMARCKIANA d'Orbigny
Plate 25, figures 29–31

Quinqueloculina lamarckiana D'ORBIGNY, 1839, in De la Sagra, Hist. Physiq. Pol. Nat. Cuba, "Foraminifères," p. 189, pl. 11, figs. 14, 15.

A variable species which is fairly common at locality 6 includes individuals closely similar to this Recent West Indian species.

QUINQUELOCULINA aff. CONTORTA d'Orbigny
Plate 25, figure 34

Quinqueloculina contorta D'ORBIGNY, 1846, Foram. Foss. Bass. Tert. Vienne, p. 298, pl. 20, figs. 4–6.

Specimens from locality 6 somewhat resemble this species described from the Miocene of the Vienna Basin, but are shorter and broader.

QUINQUELOCULINA ORBICULATA
Cushman & Stainforth, n. sp.
Plate 25, figure 32

Test rather small, rounded, nearly as broad as long, thick and rounded in end view, periphery broadly rounded; chambers quinqueloculine, increasing rapidly in size as added, rounded in transverse section; sutures distinct, slightly depressed; wall smooth, polished; aperture low and broad, curved, with a thickened lip and small, flattened tooth. Length, 0.20–0.23 mm.; breadth, 0.20–0.22 mm.; thickness, 0.18–0.20 mm.

Holotype (Cushman Collection No. 63768) from the Eocene San Mateo formation, subsurface core material from a well near Manta, Ecuador. The species is fairly common at the type locality, 6, and rare at locality 7. It somewhat resembles *Triloculina globosa* (Hanna & Hanna), described from the Eocene of Washington, but differs in the quinqueloculine arrangement of the chambers and the broader and lower aperture.

Genus SPIROLOCULINA d'Orbigny, 1826
SPIROLOCULINA JARVISI Cushman & Todd
Plate 25, figure 36

Spiroloculina jarvisi CUSHMAN & TODD, 1944, Cushman Lab. Foram. Research Spec. Pub. 11, p. 14, pl. 3, fig. 9.

Specimens from locality 6 have been compared with the types from the upper Eocene of Trinidad and seem identical.

Genus SIGMOILINA Schlumberger, 1887
SIGMOILINA TENUIS (Czjzek)
Plate 25, figure 35

(For earlier references see CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Spec. Pub. 15, p. 10, pl. 2, fig. 4); CUSHMAN, 1946, idem, Contr., vol. 22, p. 32, pl. 5, figs. 13–15; —— & GRAY, idem, Spec. Pub. 19, p. 5, pl. 1, figs. 14–16.

This species evidently has a fairly long range and wide distribution. Typical specimens occur in material from localities 6 and 7.

Genus TRILOCULINA d'Orbigny, 1826
TRILOCULINA TRICARINATA D'Orbigny
Plate 25, figure 37

(For earlier references see CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Contr., vol. 21, p. 83, pl. 13, fig. 15); CUSHMAN & GRAY, 1946, idem, Spec. Pub. 19, p. 6, pl. 1, fig. 18.

This species has been widely recorded from Eocene to Recent. Specimens from localities 6 and 7 seem typical and are very similar to those recently recorded from the upper Eocene Moodys marl member of the Jackson formation of Mississippi.

TRILOCULINA cf. GLOBOSA (Hanna & Hanna)
Plate 25, figure 33

Quinqueloculina globosa HANNA & HANNA, 1924, Univ. Washington Pub. Geol., vol. 1, no. 4, p. 58, pl. 13, figs. 1, 2.
Triloculina globosa BECK, 1943, Jour. Paleontology, vol. 17, p. 594, pl. 100, figs. 3, 4.

A single specimen from locality 6 may be referred to this species, known only from the Eocene of Cowlitz River, Lewis County, Washington. The apertural characters are not the same, however, but more specimens are needed to clarify the identity.

Genus PYRGO Defrance, 1824
PYRGO DANVILLENSIS Howe & Wallace
Plate 25, figure 38

Pyrgo inornata (D'ORBIGNY) var. *danvillensis* HOWE & WALLACE, 1932, Louisiana Dept. Cons. Geol. Bull. 2, p. 21, pl. 2, fig. 1; ELLISOR, 1933, Am. Assoc. Petroleum Geologists Bull., vol. 17, pl. 7, fig. 13; BERGQUIST, 1942, Mississippi Geol. Survey Bull. 49, p. 26, pl. 2, figs. 15, 16.

This form, known from the Jackson Eocene of Louisiana, Texas and Mississippi, seems to be sufficiently distinct from d'Orbigny's species to be worthy of specific rank. Specimens occur at localities 6 and 7.

PYRGO PSEUDOINORNATA
Cushman & Stainforth, n. sp.
Plate 25, figure 39

Test subglobular, slightly longer than broad and usually nearly as thick as wide, periphery broadly rounded, nearly circular in front view; chambers inflated, distinct;

suture distinct, somewhat depressed; wall smooth; aperture broadly oval with a slightly thickened border and a low, broad tooth, in some specimens slightly indented in the middle. Length, 0.68–1.00 mm.; breadth, 0.62–0.90 mm.; thickness, 0.55–0.90 mm.

Holotype (Cushman Collection No. 63779) from Eocene San Mateo formation subsurface core material from a well near Manta, Ecuador (locality 6). The species is common at the type locality. It differs from *P. inornata* (d'Orbigny) in the shorter, more rounded form, and the lower and broader aperture.

Family TROCHAMMINIDAE
Genus TROCHAMMINA Parker & Jones, 1859
TROCHAMMINA sp.

Specimens of this genus were obtained from localities 6, 7 and 9, but all are so greatly distorted in fossilization that it is impossible to refer them to any definite species.

Family LAGENIDAE
Genus ROBULUS Montfort, 1808
ROBULUS INSUETUS Cushman & Stainforth
Plate 25, figure 42

Robulus insuetus CUSHMAN & STAINFORTH, 1947, Cushman Lab. Foram. Research Cont. vol. 23, p. 77, pl. 17, fig. 1.

Test closely coiled, strongly umbonate, periphery acute with a narrow keel, somewhat lobulate; chambers, nine to 12, distinct, not inflated, increasing very gradually in size as added; sutures thick, with high ridges, very slightly curved, fusing at the center into an irregular umbonal boss; wall smooth except for the raised sutures; aperture peripheral, radiate. Diameter, 0.75–0.90 mm.; thickness, 0.40–0.45 mm.

This species was described from the Eocene Jusá formation, between the two main tributaries of Rio Jusá, 14 to 15 km. east-southeast of Colonche, Ecuador, locality 5. (This is a correction of the type locality as recorded in the original description.) The species is fairly common at this locality but was not found elsewhere.

ROBULUS CHIRANUS Cushman & Stone
Plate 25, figure 41

Robulus chiranus CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 5, pl. 1, fig. 15; CUSHMAN, STEWART & STEWART, 1947 (1948), Oregon Dept. Geol. & Min. Ind. Bull. 36, pt. 5, p. 98, pl. 12, fig. 5.

This species, described from the upper Eocene Chira shale of Peru, is abundant in our material from locality 6. It also occurs in the Eocene of the western coast of the United States.

ROBULUS COALEDENSIS Detling
Plate 25, figure 40

Robulus coaledensis DETLING, 1946, Jour. Paleontology, vol. 20, p. 353, pl. 48, fig. 1; CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 5, pl. 1, fig. 9.

The types of this species are from the Lower Tertiary middle Coaledo formation of Oregon. It also occurs in the Eocene Chira shale of Peru. A single specimen from locality 10 was the only one found in our Ecuador material.

ROBULUS cf. INORNATUS (d'Orbigny)

Rare and rather poorly preserved specimens are referred to this species with considerable question. They are from localities 4, 5, 6, 7, 8 and 12.

ROBULUS cf. CULTRATUS Montfort

Specimens from localities 6 and 12 may be questionably referred to this species.

Other specimens of *Robulus* are represented by poor or single specimens and cannot be specifically identified with any certainty.

Genus PLANULARIA Defrance, 1824
PLANULARIA cf. CLARA Cushman & Jarvis
Plate 25, figure 43

Planularia clara CUSHMAN & JARVIS, 1929, Cushman Lab. Foram. Research Contr., vol. 5, p. 7, pl. 2, figs. 14, 15; RENZ, 1942, 8th Am. Sci. Congress Proc., pp. 553, 556 (lists); CUSHMAN & RENZ, 1947, Cushman Lab. Foram. Research Spec. Pub. 22, p. 13, pl. 3, fig. 12; RENZ, 1948, Geol. Soc. America Mem. 32, p. 150, pl. 4, fig. 4.

Specimens from locality 5 are referred to this species with some question. They do not have the fully developed keel or as elevated sutures as the types but are evidently related to it.

PLANULARIA sp. A
Plate 25, figure 44

The single specimen, from locality 12, is figured. More are needed to warrant specific identification.

PLANULARIA sp. B
Plate 25, figure 45

The specimen figured, from locality 6, is the only one found. In some of its characters it suggests a relationship with *P. tolmani* Cushman & Simonson (1944, p. 195, pl. 30, figs. 13, 14) from the Tumey formation of California which has also been recorded from the Eocene Chira shale of Peru (Cushman and Stone, 1947, p. 5, pl. 1, fig. 12), but more specimens are needed to make a specific identification with any certainty.

Genus MARGINULINA d'Orbigny, 1826
MARGINULINA cf. EXIMIA Neugeboren
Plate 26, figure 2

Specimens from locality 6 may be referred to this species with some question.

MARGINULINA cf. ATTENUATA Neugeboren
Plate 26, figure 3

Rare specimens from locality 12 are elongate and resemble this species, but more specimens are needed to confirm the identity.

Genus DENTALINA d'Orbigny, 1826
DENTALINA cf. COMMUNIS d'Orbigny
Plate 26, figure 4

Very rare specimens from locality 5 may be referred to this widely recorded species which, from the figures referred to it, is very variable.

DENTALINA? cf. MUCRONATA Neugeboren
Plate 26, figure 1

Abundant specimens from locality 5 are referred to this species with some question, as the last chamber is missing in all specimens.

Genus NODOSARIA Lamarck, 1812
NODOSARIA CHIRANA Cushman & Stone
Plate 26, figure 5

Nodosaria chirana CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 6, pl. 1, figs. 18–21.

Specimens similar to the types of this species, described from the Eocene Chira shale of Peru, occur at localities 4, 5, 6 and 7.

Genus PSEUDOGLANDULINA Cushman, 1929
PSEUDOGLANDULINA LAEVIGATA (d'Orbigny)
Plate 26, figure 6

Nodosaria (Glandulina) laevigata D'ORBIGNY, 1826, Annales sci. nat., vol. 7, p. 252, pl. 10, figs. 1–3.

Many specimens referred to this species since d'Orbigny's time may not be conspecific, and it is difficult to give a complete synonymy. Rare specimens from localities 6 and 7 seem to be close to the typical form of the species.

PSEUDOGLANDULINA cf. TURBINATA Detling
Plate 26, figure 7

Pseudoglandulina turbinata DETLING, 1946, Jour. Paleontology, vol. 20, p. 354, pl. 48, fig. 8; CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 7, pl. 1, fig. 23.

Numerous specimens from locality 6 have the general characters of this species except that they are mostly broadly rounded at the base instead of coming to a point as in the types. This species was described from the Lower Tertiary of Coos Bay, Oregon, and has been recorded from the Eocene Chira shale of Peru.

Genus SARACENARIA Defrance, 1824
SARACENARIA HANTKENI Cushman
Plate 26, figure 9

(For references see CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 7, pl. 1, fig. 22.)

This species is widely distributed in the American and European Eocene. On the west coast it is recorded from the Eocene of Cowlitz River, Lewis County, Washington, from Coos Bay, Oregon, and from the Chira shale of Peru. Small but rather typical specimens occur at locality 5.

Genus VAGINULINA d'Orbigny, 1826
VAGINULINA SAUNDERSI (Hanna & Hanna)
Plate 26, figure 8

Cristellaria saundersi HANNA & HANNA, 1924, Univ. Washington Pub. Geol., vol. 1, p. 61, pl. 13, figs. 5, 6, 15.
Vaginulinopsis saundersi BECK, 1943, Jour. Paleontology, vol. 17, p. 598, pl. 105, figs. 1, 2, 4, 5, 10.

The types of this species are from the Eocene of Cowlitz River, Lewis County,

Washington. Rare specimens from locality 6 seem to belong to this species.

Genus LAGENA Walker & Jacob, 1798

LAGENA ACUTICOSTA Reuss
Plate 26, figure 10

Many different forms have been assigned to this species. Specimens from locality 6, one of which is figured, seem fairly typical and rather constant in their characters.

LAGENA RARICOSTA (d'Orbigny)
Plate 26, figure 11

Oolina raricosta D'ORBIGNY, 1839, Voy. Amer. Merid., vol. 5, pt. 5, "Foraminifères," p. 20, pl. 5, figs. 10, 11.

Lagena isabella (D'ORBIGNY) var. *raricosta* REUSS, 1862, Akad. Wiss. Wien. Sitzungsber., vol. 46, pt. 1, pl. 4, fig. 56.

Lagena raricosta BERTHELIN, 1878, Soc. Acad. Nantes Ann., ser. 5, vol. 8, p. 32; HERON-ALLEN & EARLAND, 1932, Discovery Repts., vol. 4, p. 369.

The few records for this species are from the present oceans. Numerous specimens from locality 6 and rare ones from locality 8 seem identical with this species.

LAGENA cf. STRIATA Williamson
Plate 26, figure 12

Specimens from locality 6 may be referred to this species, although like many others similarly identified they are not entirely like the figures of the type, which was collected near the British Isles.

LAGENA cf. GRACILICOSTA Reuss
Plate 26, figure 13

Lagena gracilicosta REUSS, 1862, Akad. Wiss. Wien Sitzungsber., vol. 46, pt. 1, p. 327, pl. 3, figs. 42, 43; ——, 1864, idem, vol. 50, pt. 1, p. 454; ——, 1865, Akad. Wiss. Wien Denkschr., vol. 25, p. 127; ——, 1870, Akad. Wiss. Wien Sitzungsber., vol. 62, pt. 1, p. 467; CLODIUS, 1922, Archiv. Ver. Freunde Nat. Mecklenberg, 75 Jahr., p. 106; FRANKE, 1927, Danmarks geol. Undersøgelse, II, Raekke 46, p. 20, pl. 2, fig. 2; TEN DAM, 1944, Geol. Stichting Meded., ser. C–V, no. 3, p. 103.

Specimens from locality 6 seem to be closer to this species than any other. The body of the test is subglobular with a short neck, and the globular portion is ornamented with a series of very fine longitudinal costae. It is very similar to the form figured by Beck (1943, p. 602, pl. 107, fig. 26) as "*Lagena* sp. a" from the Eocene of Cowlitz River, Lewis County, Washington.

LAGENA cf. LAEVIS (Montagu)
Plate 26, figure 14

A few specimens from locality 6 may be referred to this species with considerable question.

LAGENA sp.
Plate 26, figure 15

The figured specimen of this peculiar form from locality 6 is the only one found. It resembles specimens recorded from the Cocoa sand of Alabama as "*Lagena* sp. B" (Cushman, 1946, p. 18, pl. 4, fig. 11).

Family POLYMORPHINIDAE
Genus GLOBULINA d'Orbigny, 1839
GLOBULINA cf. MINUTA (Roemer)
Plate 26, figure 16

(For references see CUSHMAN, 1935, U. S. Geol. Survey Prof. Paper 181, p. 27, pl. 9, fig. 23, and CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Contr., vol. 21, p. 89, pl. 14, fig. 16.)

Rare specimens from locality 6 seem to belong to this widely recorded species.

Genus SIGMOMORPHINA Cushman & Ozawa, 1928

SIGMOMORPHINA TRINITATENSIS
Cushman & Ozawa
Plate 26, figure 22

Sigmomorphina trinitatensis CUSHMAN & OZAWA, 1930, U. S. Nat. Mus. Proc., vol. 77, art. 6, p. 134, pl. 36, figs. 1, 2; CUSHMAN & STAINFORTH, 1945, Cushman Lab. Foram. Research Spec. Pub. 14, p. 34, pl. 5, fig. 5.

The types of this species are from the Eocene of Trinidad and it has been recorded from the Eocene of Vincentown, New Jersey, and the Oligocene Cipero formation of Trinidad. Specimens, evidently immature, from localities 6, 7 and 12 seem very close to the types. The form figured from the Eocene Chira shale of Peru as "*Sigmoidella* sp." (Cushman and Stone, 1947, p. 10, pl. 1, fig. 26) is probably the same. More and further developed specimens are needed to confirm the identification.

Family NONIONIDAE
Genus NONION Montfort, 1808
NONION DANVILLENSE Howe & Wallace
Plate 26, figure 17

(For references see CUSHMAN, 1946, Cushman Lab. Foram. Research Spec. Pub. 16, p. 21, pl. 4, fig. 25.)

This is a common species of the Jackson Eocene. The types are from the Jackson of Louisiana and it has been recorded from the Moodys marl and Cocoa sand of Alabama. Specimens from locality 5 are very typical.

NONION PLANATUM Cushman & Thomas
Plate 26, figure 18

(For references see CUSHMAN, 1946, Cushman Lab. Foram. Research Spec. Pub. 16, p. 21, pl. 4, fig. 24.)

This species is recorded to range from the Claiborne Eocene through the Jackson Eocene and into the lower Oligocene. It is very rare at locality 6.

NONION ECUADORANUM
Cushman & Stainforth, n. sp.
Plate 26, figures 19, 20

Test small, umbilicate, periphery rounded, becoming much broader as growth progresses; chambers distinct, somewhat inflated, averaging about eight in the adult whorl, increasing rather rapidly in size and particularly in thickness as added; sutures distinct, only slightly depressed, very gently curved; wall smooth; aperture a low opening at the base of the apertural face of the last formed chamber and extending nearly to the umbilicus at each side. Length, 0.35–0.40 mm.; breadth, 0.25–0.33 mm.; thickness, 0.22–0.25 mm.

Holotype (Cushman Collection No. 63071) from the Eocene Jusá formation between the two main tributaries of Rio Jusá 14 to 15 km. east-southeast of Colonche, Ecuador (locality 5). This species is common at the type locality and it also occurs at localities 6, 7 and 8. It differs from *N. olssoni* (W. Berry) in the greater proportional length, rapid increase in size of the chambers, and broad periphery.

Genus NONIONELLA Cushman, 1926
NONIONELLA HANTKENI
(Cushman & Applin) vars.
Plate 26, figures 21, 24

Nonionina hantkeni CUSHMAN & APPLIN, 1926, Am. Assoc. Petroleum Geologists Bull., vol. 10, p. 182, pl. 10, figs. 10, 11.
Nonionella hantkeni (CUSHMAN & APPLIN) var. *spissa* CUSHMAN, 1931, Cushman Lab. Foram. Research Contr., vol. 7, p. 58, pl. 7, fig. 13.

Specimens fairly common at locality 10, but not found elsewhere, are referable to this variable species, especially to the variety *spissa*, known from the upper Eocene and lower Oligocene of the Gulf Coastal region of the United States.

Family HETEROHELICIDAE
Genus BOLIVINOPSIS Yakovlev, 1891
BOLIVINOPSIS PULCHELLA
Cushman & Stainforth
Plate 26, figures 30, 31

Bolivinopsis pulchella CUSHMAN & STAINFORTH, 1947, Cushman Lab. Foram. Research Contr., vol. 23, p. 78, pl. 17, figs. 4, 5.

Test elongate, strongly compressed, periphery acute but not keeled, center somewhat thickened, base broadly rounded, broad, sides slightly divergent; chambers numerous, the earlier ones close-coiled forming about one and one-half coils, then biserial throughout the adult stage, increasing very gradually in size as added, with as many as ten pairs in the adult; sutures distinct, flush with the surface, strongly oblique; wall thin, finely perforate; aperture elongate, in the terminal face extending to the inner margin. Length, 0.55–0.80 mm.; breadth, 0.22–0.25 mm.; thickness, 0.10–0.12 mm.

This species was described from locality 6 where it is common. It might be mistaken for a *Bolivina* if the early stages were missing.

Genus GÜMBELINA Egger, 1899
GÜMBELINA VENEZUELANA Nuttall
Plate 26, figure 23

(For references see CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 10, pl. 11, fig. 28.)

The types are from the Eocene of Venezuela and this species is recorded from the Jackson upper Eocene of Mississippi and Alabama, cores from the western Atlantic, the Lodo formation of California, and the

Chira shale of Peru. Specimens were found in our material only at locality 5.

Genus PLECTOFRONDICULARIA Liebus, 1903
PLECTOFRONDICULARIA COOKEI Cushman
Plate 26, figure 25

Plectofrondicularia cookei CUSHMAN, 1933, Cushman Lab. Foram. Research Contr., vol. 9, p. 11, pl. 1, fig. 26; ——, 1935, U. S. Geol. Survey Prof. Paper 181, p. 34, pl. 12, figs. 11, 12; CORYELL & EMBICH, 1937, Jour. Paleontology, vol. 11, p. 303, pl. 42, fig. 14; BERMUDEZ, 1938, Soc. cubana hist. nat. Mem., vol. 12, p. 19; MARTIN, 1943, Stanford Univ. Pub., Univ. Ser., Geol. Sci., vol. 3, no. 3, p. 12 (list); CUSHMAN & STAINFORTH, 1945, Cushman Lab. Foram. Research Spec. Pub. 14, p. 36, pl. 5, fig. 12.

The types of this species are from the Jackson Eocene of South Carolina and it is recorded from the Eocene of Cuba, Panama and California, with a few other less definite records from the Oligocene and Miocene. Specimens from locality 6 seem to be typical.

PLECTOFRONDICULARIA PACKARDI
Cushman & Schenck

(For references see CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 11, pl. 2, fig. 4.)

The records for this species include the Eocene and Oligocene of Washington, Oregon and California, and the Eocene Chira shale of Peru. A single small specimen from locality 8 is the only one found in this material.

PLECTOFRONDICULARIA PACKARDI
var. MULTILINEATA Cushman
& Simonson
Plate 26, figure 26

(For references see CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 11, pl. 2, fig. 5.)

The records for this variety include the Oligocene of California, Lower Tertiary of Oregon, and the Eocene Chira shale of Peru. Specimens assigned to it are common at locality 5.

PLECTOFRONDICULARIA VAUGHANI Cushman
Plate 26, figure 27

(For references see CUSHMAN & STAINFORTH, 1945, Cushman Lab. Foram. Research Spec. Pub. 14, p. 36, pl. 5, fig. 13.)

Apparently more than one species has been included under this name. The species has been recorded from Eocene to Miocene but the original specimens need to be checked with the types. Specimens from localities 6 and 7 are referred here but are somewhat variable.

PLECTOFRONDICULARIA DENTIFERA
Cushman & Stainforth
Plate 26, figures 28, 29

Plectofrondicularia dentifera CUSHMAN & STAINFORTH, 1947, Cushman Lab. Foram. Research Contr., vol. 23, p. 77, pl. 7, figs. 2, 3.

Test small, about twice as long as wide, very strongly compressed, periphery subacute and somewhat dentate; chambers distinct, not inflated, earlier ones of about half the test, biserial, the last two or three in the adult uniserial, the periphery extending out into a short angular projection; sutures distinct, not depressed; wall smooth; aperture terminal, elliptical, occasionally with a very short neck. Length, 0.45–0.55 mm.; breadth, 0.25–0.28 mm.; thickness, 0.04–0.06 mm.

This species was described from locality 5 where it is very common.

The details of the type locality, erroneously recorded in the original description, should be corrected to: Eocene Juså formation, between the two main tributaries of Rio Juså, 14 to 15 km. east-southeast of Colonche, Ecuador.

Genus AMPHIMORPHINA Neugeboren, 1850
AMPHIMORPHINA spp.

Species belonging to the upper Eocene group of *A. lirata* Cushman & Bermudez, *A. ignota* Cushman & Siegfus and *A. yazooensis* Bergquist have been described from locality 7 (Stainforth, 1948, p. 129, pl. 24, figs. 9–11).

Genus NODOGENERINA Cushman, 1927
NODOGENERINA cf. ROHRI
Cushman & Stainforth
Plate 26, figure 32

Nodogenerina rohri CUSHMAN & STAINFORTH, 1945, Cushman Lab. Foram. Research Spec. Pub. 14, p. 39, pl. 5, fig. 26.

A single specimen from locality 7 was compared with the types of this species from the Oligocene Cipero formation of Trinidad, and while it is somewhat smaller it has the

same granular upper part of each chamber as the types. More specimens are needed to confirm the identification.

NODOGENERINA sp.
Plate 26, figure 33

A single specimen from locality 12 probably belongs in this genus but more specimens are needed for a specific identification.

Family BULIMINIDAE
Genus BULIMINELLA Cushman, 1911
BULIMINELLA PERUVIANA
Cushman & Stone
Plate 26, figure 34

Buliminella peruviana CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 12, pl. 2, figs. 7–9.

This species, described from the Eocene Chira shale of Peru, occurs in typical form but very rarely at locality 8.

BULIMINELLA PERUVIANA var. OBESA
Cushman & Stainforth, n. var.
Plate 26, figure 35

This variety differs from the typical form in the more inflated chambers, much deeper sutures, the deeply depressed spiral suture, and the lobular periphery.

Holotype of variety (Cushman Collection No. 63711) from the Eocene Jusá formation, between the two main tributaries of Rio Jusá, 14 to 15 km. east-southeast of Colonche, Ecuador. The variety is abundant here at locality 5.

BULIMINELLA CHIRANA Cushman & Stone
Plate 26, figure 36

Buliminella chirana CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 13, pl. 2, fig. 10.

Specimens that seem to be identical with this species, described from the Eocene Chira shale of Peru, are common at localities 8 and 9.

Genus BULIMINELLITA Cushman & Stainforth, 1947
BULIMINELLITA MIRIFICA
Cushman & Stainforth
Plate 26, figures 37–39

Buliminellita mirifica CUSHMAN & STAINFORTH, 1947, Cushman Lab. Foram. Research Contr., vol. 23, p. 78, pl. 17, figs. 6–8.

Test small, irregularly fusiform, initial end subacute, greatest breadth slightly above the middle, circular in transverse section, apertural end tapering to a subacute point; chambers distinct, slightly inflated, three to five to a whorl, increasing very slightly in size as added; sutures distinct, slightly depressed, the spiral suture distinct and continuous; wall smooth; aperture in the early stage elongate, loop-shaped, in the adult terminal, rounded, with a distinct neck. Length, 0.35–0.50 mm.; diameter, 0.16–0.20 mm.

This species was described from locality 5 and also occurs at localities 6, 7, 8 and 9. It should make a good index fossil for the upper Eocene in this area.

The details of the type locality, erroneously recorded in the original description, should be corrected to: Eocene Jusá formation between the two main tributaries of Rio Jusá, 14 to 15 km. east-southeast of Colonche, Ecuador.

Genus BULIMINA d'Orbigny, 1826
BULIMINA JACKSONENSIS Cushman
Plate 26, figure 43

(For references see CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 13, pl. 2, fig. 11, and CUSHMAN & PARKER, 1947, U. S. Geol. Survey Prof. Paper 210-D, p. 97, pl. 22, figs. 14–16.) STAINFORTH, 1948, Jour. Paleontology, vol. 22, pp. 127, 128, pl. 24, fig. 12.

This is a widely distributed species of the upper Eocene and is abundant in the Chira shale of Peru. It is common at localities 5 and 6 and less so at localities 7 and 9.

BULIMINA OVATA d'Orbigny
Plate 26, figure 44

(For references see CUSHMAN & PARKER, 1947, U. S. Geol. Survey Prof. Paper 210-D, p. 106, pl. 25, figs. 8, 9.)

This species apparently ranges from Eocene to Recent. Specimens are common at locality 7 and rather rare at locality 12.

BULIMINA STALACTA Cushman & Parker
Plate 26, figure 42

Bulimina stalacta CUSHMAN & PARKER, 1936, Cushman Lab. Foram. Research Contr., vol. 12, p. 42, pl. 7, fig. 5; —— & ——, 1947, U. S. Geol. Survey Prof. Paper 210-D, p. 99, pl. 23, fig. 4; CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 13, pl. 2, fig. 12.

?Bulimina inflata COLE (not Seguenza), 1927, Bull. Am. Paleontology, vol. 14, no. 21, p. 25, pl. 3, fig. 12.

The types of this species are from the Eocene of California. Among other records is that from the Chira shale of Peru. A single specimen was found in material from locality 7.

BULIMINA SEMICOSTATA Nuttall

(For references and figures see CUSHMAN & PARKER, 1947, U. S. Geol. Survey Prof. Paper 210-D, p. 93, pl. 21, figs. 28, 29.)

The types of the species are from the Eocene of Mexico and it is recorded from the Eocene of Cuba, Trinidad, and cores from the western Atlantic.

A single specimen from locality 1 was the only one in this material.

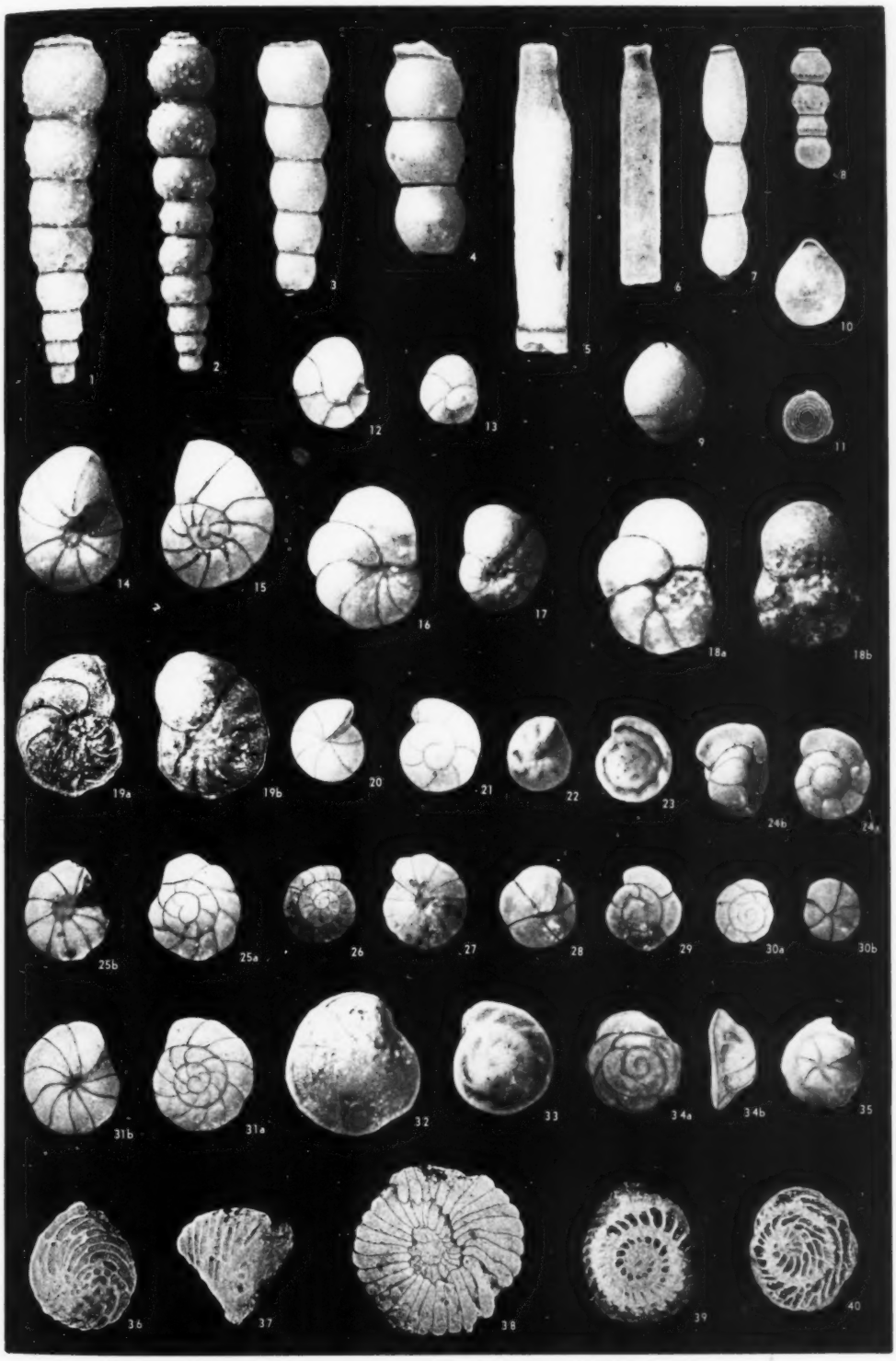
BULIMINA SECAENSIS
Cushman & Stainforth
Plate 26, figures 48, 49

Bulimina secaensis CUSHMAN & STAINFORTH, 1947, Cushman Lab. Foram. Research Contr., vol. 23, p. 79, pl. 17, figs. 9, 10.

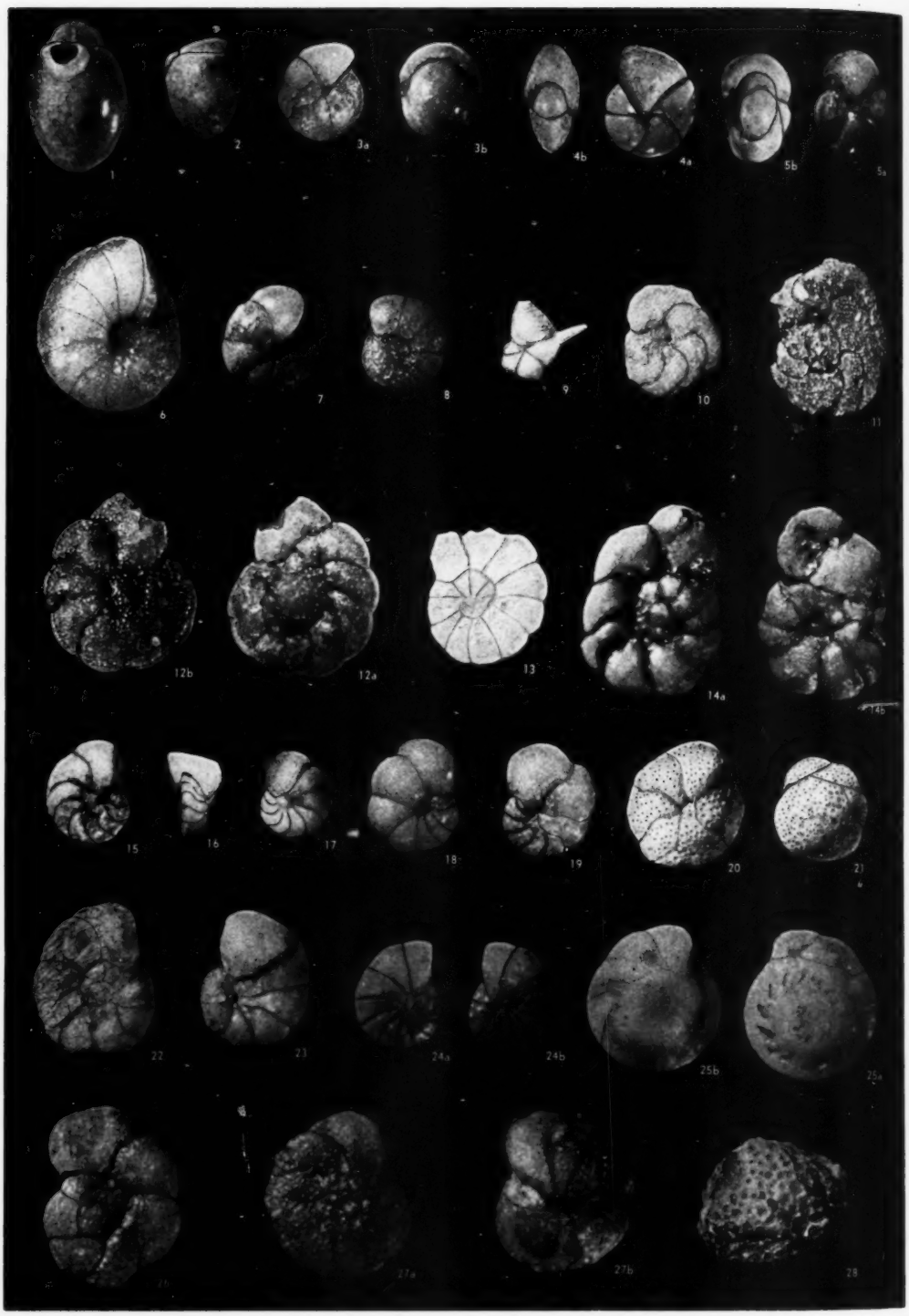
Test of medium size, tapering from the subacute to slightly rounded initial end to the greatest breadth above the middle, thence decreasing in breadth to the rounded apertural end; chambers distinct, inflated, increasing rather rapidly but evenly in size as added, the basal portion somewhat contracted; sutures distinct, strongly depressed; wall with numerous longitudinal costae, mostly continuous across but some broken at the sutures; aperture nearly terminal, loop-shaped, with the greatest width at the inner end, thence tapering to a narrow opening at the basal margin of the chamber, with a slightly developed rim. Length, 0.50–0.65 mm.; diameter, 0.32–0.38 mm.

EXPLANATION OF PLATE 27

FIG. *1*—*Ellipsonodosaria curvatura* Cushman var. A. ×35. (p. 157)
2—*Ellipsonodosaria curvatura* var. *spinea* Cushman. ×25. (p. 156)
3, 4—*Ellipsonodosaria verneuilii* (d'Orbigny). ×35. (p. 156)
5, 6—*Ellipsonodosaria* ? sp. ×35. (p. 157)
7—*Ellipsonodosaria* sp. A. ×35. (p. 157)
8—*Ellipsonodosaria* sp. B. ×35. (p. 157)
9—*Ellipsoglandulina labiata* (Schwager). ×35. (p. 157)
10—*Parafissurina* cf. *ventricosa* (Silvestri). ×35. (p. 157)
11—*Spirillina* sp. ×35. (p. 157)
12, 13—*Valvulineria texana* Cushman & Ellisor. ×35. *12*, Ventral view; *13*, dorsal view. (p. 157)
14, 15—*Discorbis samanica* (Berry). ×35. *14*, Ventral view; *15*, dorsal view. (p. 157)
16, 17—*Valvulineria samanica* (Berry). ×35. *16*, Dorsal view; *17*, ventral view. (p. 157)
18—*Valvulineria peruviana* var. *discrepans* Cushman & Stainforth, n. var. ×35. *a*, Dorsal view; *b*, ventral view. (p. 157)
19—*Valvulineria eocenica* Cushman & Stainforth, n. sp. ×25. *a*, Dorsal view; *b*, ventral view. (p. 158)
20, 21—*Gyroidina soldanii* var. *octocamerata* Cushman & Hanna. ×35. *20*, Ventral view; *21*, dorsal view. (p. 158)
22, 23—*Gyroidina orbicularis* var. *planata* Cushman. ×25. *22*, Ventral view; *23*, dorsal view; (p. 158)
24—*Gyroidina girardana* (Reuss). ×25. *a*, Dorsal view; *b*, peripheral view. (p. 158)
25—*Gyroidina chirana* Cushman & Stone. ×35. *a*, Dorsal view; *b*, ventral view. (p. 158)
26, 27—*Gyroidina scalata* Garrett. ×35. *26*, Dorsal view; *27*, ventral view. (p. 158)
28, 29—*Eponides umbonatus* (Reuss). ×35. *28*, Ventral view; *29*, dorsal view. (p. 159)
30—*Eponides minimus* Cushman. ×35. *a*, Dorsal view; *b*, ventral view. (p. 159)
31—*Eponides cocoaensis* Cushman. ×35. *a*, Dorsal view; *b*, ventral view. (p. 159)
32, 33—*Epistomina eocenica* Cushman & Hanna. ×25. *32*, Ventral view; *33* ,dorsal view. (p. 159)
34, 35—*Asterigerina crassaformis* Cushman & Siegfus. ×35. *34a*, Dorsal view; *b*, peripheral view; *35*, ventral view. (p. 159)
36–40—*Helicostegina elliotti* (Cushman & Stainforth). ×17. *36*, Ventral view showing labyrinthic chambers; *37*, peripheral view showing conical ventral side, *38*, holotype, slightly eroded specimen showing arrangement of chambers on dorsal side; *39*, transverse section of the dorsal portion; *40*, transverse section of labyrinthic ventral portion. (p. 159)



Cushman and Stainforth, Ecuador Eocene Foraminifera



Cushman and Stainforth, Ecuador Eocene Foraminifera

This species was described from locality 5 where it was abundant but has not been found elsewhere.

The details of the type locality, erroneously recorded in the original description, should be corrected to: Eocene Juså formation, between the two main tributaries of Rio Juså, 14 to 15 km. east-southeast of Colonche, Ecuador.

BULIMINA LINEATA Cushman & Stainforth
Plate 26, figure 45

Bulimina lineata CUSHMAN & STAINFORTH, 1947, Cushman Lab. Foram. Research Contr., vol. 23, p. 79, pl. 17, fig. 12.

Test rather small, slender, tapering from the slightly rounded or subacute initial end to the greatest breadth formed by the last one or two whorls, periphery only slightly lobulate, nearly circular in end view with a slight tendency to concavity at the sides; chambers distinct, only slightly inflated, numerous, increasing gradually and rather evenly in size as added; sutures distinct, slightly depressed; wall ornamented by fine longitudinal costae, continuous across the sutures, the last one or two whorls in the adult often smooth; aperture elongate, slightly oblique, in the terminal face of the last formed chamber extending from the inner margin a considerable distance into the terminal face. Length, 0.50–0.60 mm.; diameter, 0.17–0.22 mm.

This species was described from locality 6 where it is abundant and it also occurs at localities 7 and 12.

BULIMINA DECURTATA Cushman & Stainforth
Plate 26, figure 47

Bulimina decurtata CUSHMAN & STAINFORTH, 1947, Cushman Lab. Foram. Research Contr., vol. 23, p. 80, pl. 17, fig. 11.

Test rather small, very short and broad, initial end subacute, greatest breadth near the middle, apertural end broadly rounded, the last whorl making up nearly the entire surface of the test; chambers few, increasing very rapidly in size as added, inflated; sutures distinct, slightly depressed; wall smooth; aperture loop-shaped, extending from the inner margin of the last formed chamber well into the terminal face, curved, but of nearly uniform width, with a slightly thickened border. Length, 0.45–0.60 mm.; diameter, 0.40–0.50 mm.

This species was described from locality 6 and occurs rarely at locality 8.

EXPLANATION OF PLATE 28

FIG. *1*—*Chilostomelloides oviformis* (Sherborn & Chapman). ×35. (p. 160)
2—*Allomorphina trigona* Reuss. ×35. (p. 160)
3—*Pullenia duplicata* Stainforth. ×35. *a*, Side view; *b*, peripheral view. (p. 160)
4—*Pullenia quinqueloba* var. *angusta* Cushman & Todd. ×35. *a*, Side view; *b*, peripheral view. (p. 161)
5—*Pullenia quadriloba* Reuss. ×35. *a*, Side view; *b*, peripheral view. (p. 161)
6—*Anomalina alazanensis* var. *spissiformis* Cushman & Stainforth. ×35. (p. 162)
7, 8—*Anomalina chirana* Cushman & Stone. ×35. 7, Ventral view; 8, dorsal view. (p. 161)
9—*Hantkenina alabamensis* Cushman. ×35. (p. 161)
10, 11—*Planulina mexicana* Cushman. ×35. (p. 162)
12—*Planulina cocoaensis* var. *cooperensis* Cushman. ×35. *a*, Dorsal view; *b*, ventral view. (p. 162)
13—*Planulina chirana* Cushman & Stone. ×35. Dorsal view. (p. 162)
14—*Planulina crenulata* Cushman & Stone. ×35. *a*, Dorsal view; *b*, ventral view. (p. 162)
15—*Cibicides* cf. *mississippiensis* (Cushman). ×35. Dorsal view. (p. 162)
16, 17—*Cibicides mississippiensis* var. *ocalanus* Cushman. ×35. *16*, Peripheral view *17*, ventral view. (p. 163)
18, 19—*Anomalina subbadenensis* Pijpers. ×25. *18*, Dorsal view; 19, ventral view. (p. 162)
20, 21, 25—*Cibicides cookei* Cushman & Garrett. *20, 21*, ×25. *20*, Ventral view; *21*, dorsal view *25*, ×35. *a*, Dorsal view; *b*, ventral view. (p. 163)
22, 23—*Cibicides cooperensis* Cushman. ×35. *22*, Dorsal view; *23*, ventral view. (p. 163)
24—*Cibicides americanus* var. *antiquus* (Cushman & Applin). ×35. *a*, Dorsal view; *b*, ventral view. (p. 163)
26—*Cibicides* cf. *lobatulus* (Walker & Jacob). ×35. Dorsal view. (p. 163)
27—*Cibicides cicatricosus* (Schwager). ×35. *a*, Dorsal view; *b*, ventral view. (p. 163)
28—*Gypsina* cf. *globula* (Reuss). ×25. (p. 163)

BULIMINA ACUTANGULARIS Cushman & Stainforth
Plate 26, figure 46

Bulimina acutangularis CUSHMAN & STAINFORTH, 1947, Cushman Lab. Foram. Research Contr., vol. 23, p. 80, pl. 17, fig. 13.

Test small, initial end subacute, evenly tapering with the greatest breadth near the upper portion of the last whorl, apertural end obliquely truncate, irregularly triangular in transverse section, the earlier portion with acute angles; chambers rather indistinct, increasing rather rapidly in size as added; sutures rather indistinct, slightly depressed in the later portion; wall with very coarse longitudinal costae, somewhat irregular; aperture semi-elliptical, fairly large, with the greatest breadth at the base of the last formed chamber. Length, 0.37–0.42 mm.; breadth, 0.20–0.23 mm.

This species was described from locality 6 where it is common.

BULIMINA PERUVIANA Cushman & Stone

Bulimina peruviana CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 14, pl. 2, fig. 16.

A single specimen from locality 3 was the only one found in this material. The types are from the Chira shale of Peru.

BULIMINA AFFECTATA Cushman & Stainforth, n. sp.
Plate 26, figures 40, 41

Test elongate, averaging about two and one-half times as long as broad, rounded in transverse section, periphery even except in the latest portion where it is slightly indented; chambers distinct, earlier ones not inflated, later ones only slightly so, increasing in size rather rapidly as added; sutures distinct, only those of the last one or two whorls slightly depressed; wall smooth; aperture fairly large, extending well into the apertural face with a broad base. Length, 0.65–0.85 mm.; diameter, 0.25–0.30 mm.

Holotype (Cushman Collection No. 63998) from the Eocene subsurface shales in Zapotal group, subsurface material in wells drilled east of the Cerros de Estancia, Ecuador. This species is abundant at the type locality, 8. It somewhat resembles *B. microcostata* Cushman & Parker from the Eocene of California but differs in the smooth surface, more rapidly enlarging and fewer chambers, and larger aperture.

Genus GLOBOBULIMINA Cushman, 1927
GLOBOBULIMINA sp.

Single specimens from localities 6 and 10 are difficult to place in any known species until more specimens are available.

Genus ENTOSOLENIA Ehrenberg, 1848
ENTOSOLENIA HEXAGONA Williamson

Very rare specimens from locality 6 seem to belong in this species.

ENTOSOLENIA ORBIGNYANA Seguenza
Plate 26, figure 50

Very rare specimens from localities 9 and 12 may be referred to this species although in some respects they resemble *E. crumenata* Cushman.

ENTOSOLENIA cf. MARGINATA (Walker & Boys)
Plate 26, figure 51

Specimens from localities 6, 7, and 12 show considerable variation and are referred here with some question.

ENTOSOLENIA cf. LUCIDA Williamson
Plate 26, figure 52

Numerous specimens from locality 6 are referred to this species, which from its records is very variable.

Genus VIRGULINA d'Orbigny, 1826
VIRGULINA cf. DANVILLENSIS Howe & Wallace

Virgulina danvillensis HOWE & WALLACE, 1932, Louisiana Dept. Cons. Geol. Bull. 2, p. 65, pl. 11, fig. 2; CUSHMAN, 1937, Cushman Lab. Foram. Research Spec. Pub. 9, p. 9, pl. 1, figs. 28, 29; ——, 1946, idem, Spec. Pub. 16, p. 26, pl. 5, fig. 7; —— & STONE, 1947, idem, Spec. Pub. 20, p. 15, pl. 2, fig. 17.

This species is known from the Jackson Eocene of Louisiana and Alabama and from the Chira shale of Peru. A single specimen was found at locality 12.

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA MACULATA Cushman & Stone

Plate 26, figure 54

Bolivina maculata CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 17, pl. 2, fig. 21.

This species, described from the Eocene Chira shale of Peru, is very common in our Ecuadorian material, occurring at localities 1, 3, 5, 7, 8, 9, 10 and 12.

BOLIVINA BASISENTA Cushman & Stone

Plate 26, figure 53

Bolivina basisenta CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 15, pl. 2, fig. 20.

This species was also described from the Eocene Chira shale of Peru but, unlike the preceding, is very rare, occurring only at localities 5 and 6.

BOLIVINA JACKSONENSIS Cushman & Applin

Plate 26, figures 55, 56

(For references see CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 15, pl. 2, fig. 19.)

Specimens referable to this characteristic species of the Jackson Eocene are common in the Ecuador material, occurring at localities 3, 5, 6, 7, 8, 9 and 10. The specimens show some variation in relative breadth and thickness.

BOLIVINA ALAZANENSIS Cushman

Plate 26, figure 57

(For references see CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Contr., vol. 21, p. 97, pl. 15, fig. 22.)

Specimens showing considerable variation but apparently to be included in this species occur at localities 7 and 10.

Genus LOXOSTOMUM Ehrenberg, 1854

LOXOSTOMUM DALLI (Cushman)

Plate 26, figure 58

(For references see CUSHMAN, 1946, Cushman Lab. Foram. Research Spec. Pub. 16, p. 27 pl. 5, fig. 13.)

The types of this species are from the Jackson Eocene of Alabama and it has been recorded from the upper Eocene of Panama. It is very common at locality 5 and rare at locality 8.

Genus UVIGERINA d'Orbigny, 1826

UVIGERINA MANTAENSIS Cushman & Edwards

Plate 26, figure 59

(For earlier references see CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 17, pl. 2, fig. 26.) CUSHMAN & RENZ, 1947, idem, Spec. Pub. 22, p. 27; —— & —— 1948, idem, Spec. Pub. 24, p. 27.

This species, described from the sea coast near Manta, Ecuador, occurs commonly at locality 12 and rarely at locality 1.

UVIGERINA CHIRANA Cushman & Stone

Plate 26, figure 60

Uvigerina chirana CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 17, pl. 2, fig. 25.

Rare specimens of this species, described from the Eocene Chira shale of Peru, occur at locality 9.

UVIGERINA YAZOOENSIS Cushman

Plate 26, figure 61

Uvigerina yazooensis CUSHMAN, 1933, Cushman Lab. Foram. Research Contr., vol. 9, p. 13, pl. 1, fig. 29; ——, 1935, U. S. Geol. Survey Prof. Paper 181, p. 41, pl. 16, figs. 5, 6; —— & EDWARDS, 1937, Cushman Lab. Foram. Research Contr., vol. 13, p. 85, pl. 12, figs. 16, 17; BERGQUIST, 1942, Mississippi Geol. Survey Bull. 49, p. 79, pl. 8, fig. 6; CUSHMAN, 1946, Cushman Lab. Foram. Research Spec. Pub. 16, p. 29, pl. 6, fig. 2; —— & TODD, 1948, idem, Contr., vol. 24, p. 10 (list), pl. 2, fig. 7; —— & CEDERSTROM, 1949, Virginia Geol. Survey Bull. 67 (dated 1945), p. 30.

Specimens of this characteristic Jackson Eocene species occur abundantly at localities 5 and 8 and rarely at localities 10 and 12.

UVIGERINA CURTA Cushman & Jarvis

Uvigerina curta CUSHMAN & JARVIS, 1929, Cushman Lab. Foram. Research Contr., vol. 5, p. 13, pl. 3, figs. 13–15; STAINFORTH, 1948, Jour. Paleontology, vol. 22, p. 129, pl. 24, fig. 17.

This name has been applied to a variable species group with prominent lamellate costae, common in the neritic facies of the upper Eocene, especially at locality 7. The types were described from the upper Eocene San Fernando formation of Trinidad.

Family ELLIPSOIDINIDAE
Genus PLEUROSTOMELLA Reuss, 1860
PLEUROSTOMELLA OBESA Cushman & Bermudez
Plate 26, figure 62

Pleurostomella obesa CUSHMAN & BERMUDEZ, 1937, Cushman Lab. Foram. Research Contr., vol. 13, p. 16, pl. 1, fig. 61; KEIJZER, 1942, Nederlandsch Akad. Wetensch. Proc., vol. 45, p. 607 (list).

The types of this species are from the Eocene of Cuba and the only other record is from the lower Oligocene of Cuba. A single specimen from locality 6 seems to be identical.

PLEUROSTOMELLA cf. ACUTA
Hantken
Plate 26, figure 63

Rare specimens from locality 12 are referred to this species which is rather widely recorded from the Eocene.

PLEUROSTOMELLA ECUADORANA
Cushman & Stainforth, n. sp.
Plate 26, figure 64

Test elongate, circular in transverse section, initial end very broadly rounded, periphery slightly indented at the sutures; chambers few, increasing only slightly in size as added; sutures distinct, slightly depressed; wall smooth; aperture small, oval, beneath an overhanging extension of the outer end of the last formed chamber, which is slightly keeled. Length, 0.75–0.90 mm.; diameter, 0.27–0.30 mm.

Holotype (Cushman Collection No. 63899) from the Eocene San Mateo formation, outcrop on trail across the Cerro de Hoja, Ecuador. The species was found only at the type locality, 12, and specimens show very little variation. This species differs from *P. subnodosa* Reuss in the fewer chambers, nearly equal diameter throughout, and the broadly rounded initial end.

Genus ELLIPSONODOSARIA
Silvestri, 1900
ELLIPSONODOSARIA NUTTALLI var. GRACILLIMA Cushman & Jarvis
Plate 26, figure 65

(For references see CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Spec. Pub. 15, p. 55, pl. 8, fig. 13.)

Specimens apparently identical with the types of this variety are from localities 3, 7, 9 and 12. The types are from the Oligocene of Trinidad and it is also recorded from the Eocene of Cuba and the Miocene of Jamaica.

ELLIPSONODOSARIA DECURTA Bermudez
Plate 26, figure 67

Ellipsonodosaria decurta BERMUDEZ, 1937, Soc. cubana hist. nat. Mem., vol. 11, p. 144, pl. 17, figs. 13, 14; ——, 1938, idem, vol. 12, p. 5; CUSHMAN & STAINFORTH, 1945, Cushman Lab. Foram. Research Spec. Pub. 14, p. 56, pl. 10, fig. 1.

Rare specimens from localities 7 and 12 are close to this species, described from the Eocene of Cuba and recorded from the Oligocene Cipero formation of Trinidad.

ELLIPSONODOSARIA VERNEUILII
(d'Orbigny)
Plate 27, figures 3, 4

(For earlier references see CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Spec. Pub. 15, p. 54, pl. 8, fig. 9.) COLOM, 1945, Inst. Inv. Geol. Estudios Geologicos, no. 2, p. 41, pl. 1, figs. 3–6, p. 73, pl. 2, figs. 38, 43, pl. 4, figs. 79–81; ——, 1946, Inst. Inv. Geol. Estudios Geologicos, no. 3, p. 70, pl. 9, figs. 204–206; CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 210-A, p. 11; GERMERAAD, in: Rutten & Hotz, 1946, Geological, petrographical, and paleontological results of explorations in the Island of Ceram, 3d. ser., Geol., no. 2, p. 69.

Specimens of this widely recorded species were found only at locality 12.

ELLIPSONODOSARIA CURVATURA
Cushman
Plate 26, figure 66

Ellipsonodosaria curvatura CUSHMAN, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 71, pl. 12, fig. 6; —— & STAINFORTH, 1945, idem, Spec. Pub. 14, p. 56, pl. 9, fig. 16; —— & STONE, 1947, idem, Spec. Pub. 20, p. 18, pl. 2, fig. 28.

The types of this species are from the Eocene of Atlantic submarine cores and it has been recorded from the Eocene Chira shale of Peru and the Oligocene Cipero formation of Trinidad. Specimens referable to it occur at localities 5, 6, 9 and 12.

ELLIPSONODOSARIA CURVATURA var. SPINEA Cushman
Plate 27, figure 2

Ellipsonodosaria curvatura var. *spinea* CUSHMAN, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 71, pl. 12, figs. 7–11; —— & STAIN-

FORTH, 1945, idem, Spec. Pub. 14, p. 56, pl. 9, fig. 17.

This variety occurs with the typical form at the type locality and in the Oligocene of Trinidad. It is very common at locality 6 but was not found elsewhere.

ELLIPSONODOSARIA CURVATURA
Cushman, var. A
Plate 27, figure 1

A few specimens from locality 7 appear to be related to this species but are not well preserved and need more and better specimens to show the full characters.

ELLIPSONODOSARIA sp. A
Plate 27, figure 7

Rare and incomplete specimens from locality 12 cannot be specifically determined until more complete specimens are available.

ELLIPSONODOSARIA sp. B
Plate 27, figure 8

Numerous but incomplete specimens similar to that figured occur at localities 3, 4, 5, 6, 7, 8, 9 and 12. They show a considerable degree of variation in ornamentation but the form of the chambers is rather constant.

ELLIPSONODOSARIA? sp.
Plate 27, figures 5, 6

Fragmentary specimens from locality 7. Better and more complete specimens are needed for identification.

Genus ELLIPSOGLANDULINA
Silvestri, 1900

ELLIPSOGLANDULINA LABIATA (Schwager)
Plate 27, figure 9

The single figured specimen from locality 8 seems to belong to this species.

Genus PARAFISSURINA Parr, 1947

PARAFISSURINA cf. VENTRICOSA
(Silvestri)
Plate 27, figure 10

Very rare specimens from locality 6 seem related to this species.

Family ROTALIIDAE

Genus SPIRILLINA Ehrenberg, 1843

SPIRILLINA sp.
Plate 27, figure 11

A single specimen from locality 6 was the only one of this genus found in the Ecuador material. It is very small, with the two sides alike and very finely marked with radiating depressions. It does not seem to belong to any described species, but more specimens are needed to give complete specific characters.

Genus DISCORBIS Lamarck, 1804

DISCORBIS SAMANICA (Berry)
Plate 27, figures 14, 15

Truncatulina samanica BERRY, 1928, Eclogae geol. Helvetiae, vol. 21, p. 402, text-fig. 24.
Discorbis samanica CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 19, pl. 2, fig. 27.

The types of this species are from the Eocene Lobitos shales of Peru and it has been recorded from the Chira shale of Peru. In the Eocene of Ecuador the species is common at locality 12 and less common at 1, 3, 4, 5, 9 and 10. The specimens show considerable variation but the limbate dorsal sutures seem to be a constant character.

Genus VALVULINERIA Cushman, 1926

VALVULINERIA SAMANICA (Berry)
Plate 27, figures 16, 17

Anomalina samanica BERRY, 1928, Eclogae geol. Helvetiae, vol. 21, p. 402, text-fig. 22.
Valvulineria samanica CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 19, pl. 3, fig. 1.

The types of this species are also from the Eocene Lobitos shales of Peru and it is recorded from the Chira shale of Peru. Rare specimens from locality 5 seem to belong to this species.

VALVULINERIA TEXANA Cushman & Ellisor
Plate 27, figures 12, 13

(For references see CUSHMAN, 1946, Cushman Lab. Foram. Research Spec. Pub. 16, p. 31, pl. 6, fig. 13.)

The previous records of this species are from the Jackson Eocene of Texas, Louisiana, Alabama and Georgia. Rare but apparently typical specimens occur at localities 6 and 7.

VALVULINERIA PERUVIANA var. DISCREPANS Cushman & Stainforth, n. var.
Plate 27, figure 18

Variety differing from the typical form in the more elongate test, less rounded periph-

ery, and somewhat more compressed test.

Holotype of variety (Cushman Collection No. 63967) from the Eocene Zapallo formation on Rio Zapallo Grande, at a point 9 km. east southeast of Telembi, Ecuador. This variety is rather rare at the type locality 7, and rare also at locality 6.

VALVULINERIA EOCENICA Cushman & Stainforth, n. sp.
Plate 27, figure 19

Test slightly longer than broad, dorsal side flattened or even slightly concave in the earlier stages, slightly convex in the later portion, ventral side strongly convex, somewhat umbilicate, periphery acute and slightly keeled; chambers distinct, usually seven or eight in the adult whorl, strongly convex ventrally, only slightly so in the last portion of the dorsal side; sutures distinct, strongly limbate and raised on the dorsal side, strongly curved, on the ventral side depressed and nearly radial; wall smooth except for the raised sutures and keel, distinctly perforate; aperture at the ventral margin of the last formed chamber below a slightly projecting lobe. Length, 0.55–0.75 mm.; breadth, 0.50–0.55 mm.; thickness, 0.28–0.32 mm.

Holotype (Cushman Collection No. 63968) from the Eocene Zapallo formation, on Rio Zapallo Grande, at a point 9 km. east southeast of Telembi, Ecuador. The species is common at the type locality, 7, and less common at locality 6, but was not found elsewhere. It differs from *V. crassisepta* Keijzer from the Tertiary of Cuba in the sutures being depressed and not limbate and very slightly curved on the ventral side, as well as by the more open arrangement of the chambers on the dorsal side.

Genus GYROIDINA d'Orbigny, 1826
GYROIDINA CHIRANA Cushman & Stone
Plate 27, figure 25

Gyroidina chirana CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 23, pl. 3, fig. 4.

This species was described from the Eocene Chira shale of Peru. Like many other species of that formation it is common at locality 5 but was not found elsewhere.

GYROIDINA GIRARDANA (Reuss)
Plate 27, figure 24

(For references see CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 140, pl. 58, fig. 9.)

This species is widely recorded in the Tertiary and Upper Cretaceous. Specimens from localities 6, 7 and 9 seem to belong here.

GYROIDINA ORBICULARIS var. PLANATA Cushman
Plate 27, figures 22, 23

(For references see CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 22, pl. 3, fig. 5.)

Specimens from locality 6 seem to belong to this variety. It is recorded from the Jackson Eocene of South Carolina and from the Eocene Kreyenhagen shale of California, the Chira shale of Peru, and the Oligocene Lincoln formation of Washington. The Ecuador specimens do not have quite as wide or deep a whorl on the dorsal side but this varies even in the type material.

GYROIDINA SOLDANII var. OCTOCAMERATA Cushman & Hanna
Plate 27, figures 20, 21

(For earlier references see CUSHMAN, 1946, Cushman Lab. Foram. Research Spec. Pub. 16, p. 31, pl. 6, fig. 15.) CUSHMAN & STONE, 1947, idem, Spec. Pub. 20, p. 22, pl. 3, fig. 6.

Most of the records for this variety are from the upper Eocene and it has recently been recorded from the Eocene Chira shale of Peru. It is common in the Ecuador material, occurring at localities 5, 6, 7, 9 and 12.

GYROIDINA SCALATA Garrett
Plate 27, figures 26, 27

Gyroidina scalata GARRETT, 1938, Jour. Paleontology, vol. 12, p. 316, pl. 40, figs. 12, 13; CUSHMAN & ELLISOR, 1939, Cushman Lab. Foram. Research Contr., vol. 15, p. 10, pl. 2, fig. 1; ELLISOR, 1940, Am. Assoc. Petroleum Geologists Bull., vol. 24, pl. 2, fig. 8; COLOM, 1946, Inst. Inv. Geol., Estudios Geologicos, no. 3, p. 63, pl. 4, fig. 109.

The types of this species are from the Oligocene ? of deep wells of Texas. Specimens from locality 6 have been compared with paratypes of this species and seem identical.

Genus EPONIDES Montfort, 1808
EPONIDES UMBONATUS (Reuss)
Plate 27, figures 28, 29

Specimens evidently belonging to this widely recorded species occur in material from localities 4, 6, 7, 9 and 12. It is recorded from the Eocene of South Carolina, Mexico, Cuba, Venezuela and California, and from the Chira shale of Peru.

EPONIDES COCOAENSIS Cushman
Plate 27, figure 31

(For references see CUSHMAN, 1946, Cushman Lab. Foram. Research Spec. Pub. 16, p. 34, pl. 6, fig. 16.)

This species seems to be limited to the upper Eocene, recorded from Georgia, South Carolina, Alabama, Mississippi and California. It is rare in the Ecuador material, occurring only at localities 4 and 12.

EPONIDES MINIMUS Cushman
Plate 27, figure 30

(For references see CUSHMAN, 1946, Cushman Lab. Foram. Research Spec. Pub. 16, p. 34, pl. 6, fig. 17.)

Very rare but typical specimens of this upper Eocene species occur at locality 12. It is recorded from the Eocene of Georgia, South Carolina, California and Washington.

Genus PARRELLA Finlay, 1939
PARRELLA cf. MEXICANA (Cole)

Pulvinulinella culter (PARKER & JONES) var. *mexicana* COLE, 1927, Bull. Am. Paleontology, vol. 14, no. 51, p. 31, pl. 1, figs. 15, 16.

A single specimen from locality 6 seems to belong to this species.

Genus EPISTOMINA Terquem, 1883
EPISTOMINA EOCENICA
Cushman & Hanna
Plate 27, figures 32, 33

Epistomina eocenica CUSHMAN & HANNA, 1927, San Diego Soc. Nat. History Trans., vol. 5, p. 53, pl. 5, figs. 4, 5; WIENZIERL & APPLIN, 1929, Jour. Paleontology, vol. 3, p. 407; CUSHMAN & MCMASTERS, 1936, idem, vol. 10, p. 515, pl. 76, fig. 5.

Rare specimens from localities 3, 6 and 7 seem to belong to this Eocene species. Not all of the references to it appear to be of typical specimens. Similar specimens occur in the Chira shale of Peru.

Genus FERAYINA Frizzell, 1949
FERAYINA PERUVIANA Frizzell

Dictyoconus sp. STAINFORTH, 1948, Jour. Paleontology, vol. 22, p. 146.
Ferayina peruviana FRIZZELL, 1949, Jour. Paleontology, vol. 23, p. 486, text-figs. 7a, b.

This species is known from orbitoidal sand near the base of the Socorro formation, stratigraphically intermediate in level between units 4 and 9 of this paper. The few specimens so far noted (Cushman Collection No. 63684) came from a single sample collected on the beach at Ancon Point, 150 meters south of the pumphouse.

Family AMPHISTEGINIDAE
Genus ASTERIGERINA d'Orbigny, 1839
ASTERIGERINA CRASSAFORMIS
Cushman & Siegfus
Plate 27, figures 34, 35

Asterigerina crassaformis CUSHMAN & SIEGFUS, 1935, Cushman Lab. Foram. Research Contr., vol. 11, p. 94, pl. 14, fig. 10; —— & ——, 1942, San Diego Soc. Nat. History Trans., vol. 9, no. 34, p. 420, pl. 18, fig. 1; KELLEY, 1943, Am. Assoc. Petroleum Geologists Bull., vol. 27, pp. 8, 11 (lists); CURRAN, 1943, idem, pp. 1378, 1381 (lists); MARTIN, 1943, Stanford Univ. Pub., Univ. ser., Geol. Sci., vol. 3, no. 3, p. 9 (list).

Specimens from localities 9 and 12 have been compared with the types from the Eocene Kreyenhagen shale of California and seem identical. Other records are all from the California Eocene.

Genus HELICOSTEGINA Barker and Grimsdale, 1936
HELICOSTEGINA ELLIOTTI (Cushman & Stainforth)
Plate 27, figures 36–40

Amphistegina elliotti CUSHMAN & STAINFORTH, 1946, Cushman Lab. Foram. Research Contr., vol. 22, p. 118, pl. 20, figs. 1–6.

Test strongly conical in shape, the dorsal side nearly flat or only slightly convex, the ventral side nearly as deep as wide, periphery subacute; chambers of the dorsal side involute, strongly curved, the ventral side with supplementary chambers distinctly curved and in some specimens apparently tending to become slightly labyrinthic; sutures rather indistinct except in abraded specimens, but very strongly curved; wall especially on the ventral side marked by

prominent, raised papillae, the dorsal side also with distinct papillae in well preserved specimens; aperture on the ventral side, elongate, at the inner margin of the last formed chamber. Height, 0.75–1.00 mm.; diameter, 0.75–1.50 mm.

This species was described from locality 1. It was not found elsewhere.

Family CASSIDULINIDAE
Genus CASSIDULINA d'Orbigny, 1826
CASSIDULINA GLOBOSA Hantken

Typical specimens of this species are common at locality 6 and rare at localities 4 and 5. It is widely recorded and occurs in the Chira shale of Peru.

CASSIDULINA cf. CRASSA d'Orbigny

A few specimens from localities 9 and 12 seem to be related to this species.

Genus STICHOCASSIDULINA Stone, 1946
STICHOCASSIDULINA THALMANNI Stone

Stichocassidulina thalmanni STONE, 1946, Jour. Paleontology, vol. 20, p. 60, text-figs. 1, 2; STAINFORTH, 1948, idem, vol. 22, p. 127, pl. 24, fig. 26.

This distinctive species is known from localities 5, 7 and 12. Fully typical specimens are common in some samples although there is a tendency for the Ecuadorean form to be smaller, with less prominent supplementary apertures, than the form common in the Chira formation of Peru.

Family CHILOSTOMELLIDAE
Genus ALLOMORPHINA Reuss, 1850
ALLOMORPHINA TRIGONA Reuss
Plate 28, figure 2

Allomorphina trigona REUSS, 1850, Akad. Wiss. Wien Denkschr., vol. 1, p. 380, pl. 48, fig. 14; CUSHMAN & TODD, 1949, Cushman Lab. Foram. Research Contr., vol. 25, p. 67, pl. 12, figs. 1, 2.

Specimens referable to this species are common at locality 6 and a single specimen was found from locality 11.

Genus CHILOSTOMELLA Reuss, 1850
CHILOSTOMELLA cf. CYLINDROIDES Reuss

Very rare and rather poorly preserved specimens from locality 9 may be referred to this species.

Genus CHILOSTOMELLOIDES Cushman, 1926
CHILOSTOMELLOIDES OVIFORMIS (Sherborn & Chapman)
Plate 28, figure 1

Lagena (Obliquina) oviformis SHERBORN & CHAPMAN, 1886, Jour. Roy. Micro. Soc., p. 745, pl. 14, fig. 19.

Chilostomella oviformis SHERBORN & CHAPMAN, 1889, Jour. Roy. Micro. Soc., p. 485, pl. 11, fig. 13.

Chilostomelloides oviformis CUSHMAN, 1926, Cushman Lab. Foram. Research Contr., vol. 1, pt. 4, p. 77, pl. 11, figs. 17, 21; ——, 1927, Jour. Paleontology, vol. 1, p. 168, pl. 26, fig. 10; COLE, 1928, Bull. Am. Paleontology, vol. 14, no. 53, p. 216 (16); NUTTALL, 1930, Jour. Paleontology, vol. 4, p. 289; ——, 1932, idem, vol. 6, p. 28; HOWE & WALLACE, 1932, Louisiana Dept. Cons. Geol. Bull. 2, p. 73. pl. 15, fig. 5; CUSHMAN, 1933, Cushman Lab. Foram. Research Spec. Pub. 4, pl. 26, fig. 9; ——, 1933, idem, Spec. Pub. 5, pl. 33, figs. 12, 13; BERGQUIST, 1942, Mississippi Geol. Survey Bull. 49, p. 94, pl. 9, fig. 31; COLOM, 1945, Inst. Inv. Geol., Estudios Geologicos, no. 2, p. 74, pl. 5, figs. 135–139; CUSHMAN & TODD, 1949, Cushman Lab. Foram. Research Contr., vol. 25, p. 94, pl. 16, figs. 7–9.

This species was described from the Eocene London clay of England, and has been recorded from the upper Eocene and lower Oligocene of the southern United States and Mexico. Specimens are fairly common at localities 6 and 7 and rare at 9.

Genus PULLENIA Parker and Jones, 1862
PULLENIA DUPLICATA Stainforth
Plate 28, figure 3

Pullenia duplicata STAINFORTH, 1949, Jour. Paleontology, vol. 23, p. 436.

Specimens referable to this widely recorded species occur only at locality 6. It apparently ranges from Miocene to Eocene and was recently recorded from the Chira shale of Peru. The above reference gives synonymy for this species originally described from the Oligocene Septaria clay of Germany.

PULLENIA cf. ALAZANENSIS Cushman

A few poorly preserved specimens from localities 5 and 12 resemble this species described from the Oligocene Alazan shale of Mexico and recorded from the Eocene Chira shale of Peru.

PULLENIA cf. QUINQUELOBA (Reuss)

Very rare specimens from localities 6 and 9 seem close to this species.

PULLENIA QUINQUELOBA var. ANGUSTA Cushman & Todd
Plate 28, figure 4

Pullenia quinqueloba (REUSS) var. *angusta* CUSHMAN & TODD, 1943, Cushman Lab. Foram. Research Contr., vol. 19, p. 10, pl. 2, figs. 3, 4; CUSHMAN, 1946, idem, Spec. Pub. 16, p. 37, pl. 7, fig. 11; —— & TODD, 1946, idem, Contr., vol. 22, p. 63.

Most of the records for this variety are from the lower Eocene but it has recently been recorded from the upper Eocene Cocoa sand of Alabama. Rare specimens from localities 7 and 8 seem to belong to this variety.

PULLENIA QUADRILOBA Reuss
Plate 28, figure 5

Pullenia compressiuscula var. *quadriloba* REUSS, 1867, Akad. Wiss. Wien Sitzungsber., vol. 55, p. 87, pl. 3, fig. 8; GRZYBOWSKI, 1896, Akad. umiej. Krakow Rozpraw., vol. 10, p. 300, pl. 11, fig. 1.

Pullenia quadriloba CUSHMAN & TODD, 1943, Cushman Lab. Foram. Research Contr., vol. 19, p. 15, pl. 2, figs. 20, 21; —— & ——, 1945, idem, Spec. Pub. 15, p. 65, pl. 11, fig. 7.

The figured specimen from locality 6 seems to belong to this species. It is the only one found in the Ecuador material. The previous records are from the Miocene.

Family GLOBIGERINIDAE

There are numerous species of *Globigerina* in the material studied. Stainforth (1948, p. 114 et seq.) has stressed their value in zonation, mentioning *G. danvillensis* Howe & Wallace, *G. wilsoni* (?) Cole, *G. triloculinoides* (?) Beck (not Plummer), *G.* aff. *bulloides* d'Orbigny, *G.* cf. *concinna* Reuss, and *G. dissimilis* Cushman & Bermudez from the Eocene of western Ecuador. Probably other species, not yet determined, are also present.

Genus HASTIGERINELLA Cushman, 1927
HASTIGERINELLA EOCANICA Nuttall ?

Hastigerinella eocanica NUTTALL, 1928, Jour. Paleontology, vol. 2, p. 376, pl. 50, figs. 9–11; STAINFORTH, 1948, idem, vol. 22, p. 116, pl. 26, figs. 18, 19.

From locality 3 there are numerous fragments that seem to be the spinose projections of this species but no complete specimens were found. With these are still more numerous fragments that resemble the spines of *H. jarvisi* Cushman (1930, p. 18, pl. 3, figs. 8–11), known from the Eocene of Trinidad. *Hastigerinella* is the only foraminifer found consistently, though never in abundance, in the radiolarian facies developed at localities 11, 12 and 13.

Family HANTKENINIDAE
HANTKENINA ALABAMENSIS Cushman
Plate 28, figure 9

(For earlier references see CUSHMAN, 1946, Cushman Lab. Foram. Research Spec. Pub. 16, p. 37, pl. 7, fig. 17.) CUSHMAN & STONE, 1947, idem, Spec. Pub. 20, p. 25, pl. 3, figs. 14, 15; STAINFORTH, 1948, Jour. Paleontology, vol. 22, p. 127, pl. 25, fig. 3.

This species, widely recorded from the upper Eocene, is common at localities 5 and 6. It also occurs in the Chira shale of Peru.

Family GLOBOROTALIIDAE
Genus GLOBOROTALIA Cushman, 1927
GLOBOROTALIA cf. G. (TRUNCOROTALIA) CRASSATA Cushman

Globorotalia (*Truncorotalia*) *crassata* CUSHMAN & BERMUDEZ, 1949, Cushman Lab. Foram. Research Contr., vol. 25, p. 37, pl. 7, figs. 4–6.

Very rare specimens from locality 9 are much like this species but are not quite as spinose. More specimens are needed to verify the specific identity.

GLOBOROTALIA (TURBOROTALIA) CENTRALIS Cushman & Bermudez

Globorotalia centralis CUSHMAN & BERMUDEZ, 1937, Cushman Lab. Foram. Research Contr., vol. 13, p. 26, pl. 2, figs. 62–65; STAINFORTH, 1948, Jour. Paleontology, vol. 22, p. 118.

Globorotalia (*Turborotalia*) *centralis* CUSHMAN & BERMUDEZ, 1949, Cushman Lab. Foram. Research Contr., vol. 25, p. 44, pl. 8, figs. 19–21.

The typical form of this species occurs at locality 7. It is widely distributed in the upper Eocene of the Caribbean region.

Family ANOMALINIDAE
Genus ANOMALINA d'Orbigny, 1826
ANOMALINA CHIRANA Cushman & Stone
Plate 28, figures 7, 8

Anomalina chirana CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub 20, p. 25, pl. 4, fig. 1.

Typical specimens of this species, described from the Eocene Chira shale of Peru, are very common at localities 6, 7 and 12.

ANOMALINA ALAZANENSIS var. SPISSIFORMIS Cushman & Stainforth
Plate 28, figure 6

Anomalina alazanensis NUTTALL var. *spissiformis* CUSHMAN & STAINFORTH, 1945, Cushman Lab. Foram. Research Spec. Pub. 14, p. 71, pl. 14, fig. 5; CUSHMAN & TODD, 1945, idem, Spec. Pub. 15, p. 69, pl. 12, fig. 3.

Rare specimens from locality 6 resemble this variety, described from the Oligocene Cipero formation of Trinidad and recorded from the Miocene of Buff Bay, Jamaica. The Ecuador specimens are not entirely typical but closely resemble the types. It is possible that our specimens are related to *A. chirana* but more specimens are needed to check this suggestion.

ANOMALINA SUBBADENENSIS Pijpers
Plate 28, figures 18, 19

Anomalina subbadenensis PIJPERS, 1933, Geol. Pal. Bonaire, p. 72, text-figs. 116–120.

Specimens from locality 8 are fairly common and resemble this species, described from the Eocene of the Island of Bonaire. The species earlier recorded by us from the Oligocene of Trinidad (Cushman and Stainforth, 1945, p. 71, pl. 14, fig. 2) is now believed to fall under *Globorotalia* (*Turborotalia*) *mayeri* Cushman & Ellisor (see Cushman and Bermudez, 1949, p. 44, pl. 8, figs. 16–18).

Genus PLANULINA d'Orbigny, 1826
PLANULINA COCOAENSIS var. COOPERENSIS Cushman
Plate 28, figure 12

Planulina cocoaensis var. *cooperensis* CUSHMAN, 1933, Cushman Lab. Foram. Research Contr., vol. 9, p. 20, pl. 2, fig. 12; ——, 1935, U. S. Geol. Survey Prof. Paper 181, p. 52, pl. 22, fig. 8; BERGQUIST, 1942, Mississippi Geol. Survey Bull. 49, p. 99, pl. 10, figs. 5, 6; CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 25, pl. 4, fig. 2.

This variety was described from the upper Eocene of South Carolina and recorded from the upper Eocene of Mississippi and the Eocene Chira shale of Peru. A single specimen from locality 7 seems fairly typical.

PLANULINA CHIRANA Cushman & Stone
Plate 28, figure 13

Planulina chirana CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 26, pl. 4, fig. 3.

Rare specimens of this species described from the Eocene Chira shale of Peru were found at locality 5 and specimens which may be the early stages at 9 and 12.

PLANULINA CRENULATA Cushman & Stone
Plate 28, figure 14

Planulina crenulata CUSHMAN & STONE, 1947, Cushman Lab. Foram. Research Spec. Pub. 20, p. 26, pl. 4, figs. 4, 5.

Rare and somewhat contorted specimens of this species described from the Chira shale of Peru occur at locality 8. A few specimens from locality 5 may be the early stages of this species.

PLANULINA MEXICANA Cushman
Plate 28, figures 10, 11

Planulina mexicana CUSHMAN, 1927, Cushman Lab. Foram. Research Contr., vol. 3, p. 113, pl. 23, fig. 5; ——, 1927, Jour. Paleontology, vol. 1, p. 170; NUTTALL, 1932, idem, vol. 6, p. 31, pl. 7, fig. 7; HADLEY, 1934, Bull. Am. Paleontology, vol. 20, no. 70A, p. 28, pl. 4, fig. 12; PALMER & BERMUDEZ, 1936, Soc. cubana hist. nat. Mem., vol. 10, p. 312; BERMUDEZ, 1938, idem, vol. 12, p. 18; VAN BELLEN, DE WITT PUYT, RUTGERS & VAN SOEST, 1941, Nederlandsch Akad. Wetensch. Proc., vol. 44, p. 1145; GALLOWAY & HEMINWAY, 1941, New York Acad. Sci. Survey Porto Rico and Virgin Islands, vol. 3, pt. 4, p. 399, pl. 26, fig. 3.

The types of this species are from the lower Oligocene Alazan clay of Mexico. It has been recorded also from the lower Oligocene of Cuba, the Ponce formation of Porto Rico, and the Eocene of Cuba. The two specimens figured from locality 6 are close to the types in character and are the only ones found in the Ecuador material.

Genus CIBICIDES Montfort, 1808
CIBICIDES cf. MISSISSIPPIENSIS (Cushman)
Plate 28, figure 15

Fairly common specimens from localities 4, 6, 7, 8, 10 and 12 resemble this species.

CIBICIDES MISSISSIPPIENSIS var. OCALANUS Cushman
Plate 28, figures 16, 17

Cibicides mississippiensis (CUSHMAN) var. *ocalanus* CUSHMAN, 1935, U. S. Geol. Survey Prof. Paper 181, p. 54; APPLIN & JORDAN, 1945, Jour. Paleontology, vol. 19, pp. 130 (list), 148.

This variety is known from the upper Eocene of Florida, Georgia, Alabama and South Carolina. Specimens compared with the types and appearing identical are from localities 1, 6, 7 and 12.

CIBICIDES cf. PRAECONCENTRICUS Cushman

Cibicides praeconcentricus CUSHMAN, 1945, Cushman Lab. Foram. Research Contr., vol. 21, p. 10, pl. 2, fig. 14.

A single specimen from locality 3 was compared with the type of this species from the Jackson Eocene of Georgia and seems very similar.

CIBICIDES COOKEI Cushman & Garrett
Plate 28, figures 20, 21, 25

Cibicides cookei CUSHMAN & GARRETT, 1938, Cushman Lab. Foram. Research Contr., vol. 14, p. 65, pl. 11, fig. 3.

Numerous specimens from localities 6, 7 and 9 are very close to the types of this species, described from the lower Oligocene of Alabama. Also included here tentatively are a few large individuals from locality 7 (pl. 28, fig. 25) which possibly represent a mature growth stage.

CIBICIDES AMERICANUS var. ANTIQUUS (Cushman & Applin)
Plate 28, figure 24

(For references see CUSHMAN & TODD, 1945, Cushman Lab. Foram. Research Contr., vol. 21, p. 104, pl. 16, figs. 21, 22.)

Very rare specimens from locality 8 seem to belong to this variety which is characteristic of the Jackson Eocene.

CIBICIDES CICATRICOSUS (Schwager)
Plate 28, figure 27

(For references see CUSHMAN & STAINFORTH, 1945, Cushman Lab. Foram. Research Spec. Pub. 14, p. 73, pl. 15, fig. 6.)

A single specimen from locality 8 seems to belong to this species, known from the Pliocene and Oligocene.

CIBICIDES COOPERENSIS Cushman
Plate 28, figures 22, 23

Cibicides cooperensis CUSHMAN, 1933, Cushman Lab. Foram. Research Contr., vol. 9, p. 20, pl. 2, fig. 11; ——, 1935, U. S. Geol. Survey Prof. Paper 181, p. 53, pl. 23, fig. 3.

The only records for this species are from the upper Eocene Cooper marl of South Carolina. Rare specimens from locality 8 were compared with the types and seem identical.

CIBICIDES cf. LOBATULUS (Walker & Jacob)
Plate 28, figure 26

Numerous specimens from locality 6 seem closely related to this species which has been widely recorded. In some respects they resemble the line drawings of "*Truncatulina lobatula* var. *peruviana*" of Berry (1928, p. 400, text-fig. 10) from the Saman shale of Peru. The specimens, however, do not agree with the description given as they have a coarsely perforate test and are not biconvex.

CIBICIDES PERLUCIDUS Nuttall

Cibicides perlucida NUTTALL, 1932, Jour. Paleontology, vol. 6, p. 33, pl. 8, figs. 10–12; STAINFORTH, 1948, idem, vol. 22, p. 129, pl. 25, figs. 8–10.

This large and distinctive species has been recorded in Eocene and early Oligocene faunas at widely separated localities (see second of references above), to which we can add northwest Peru (Verdun formation, etc.). In Ecuador it is known from localities 1, 3, 4, 5 and 7; never in abundance though conspicuous when present. The degree of ventral convexity, pronounced in immature specimens, decreases with increasing size.

Family PLANORBULINIDAE
Genus GYPSINA Carter, 1877
GYPSINA cf. GLOBULA (Reuss)
Plate 28, figure 28

A single specimen from locality 1 is incomplete and may be placed in this species with some question.

REFERENCES

BECK, R. S., 1943, Eocene Foraminifera from Cowlitz River, Lewis County, Washington: Jour. Paleontology, vol. 17, pp. 584–614.
BERRY, W., 1928, The smaller Foraminifera of the middle Lobitos shales of northwestern

Peru: Eclogae geol. Helvetiae, vol. 21, pp. 390–405.

CUSHMAN, J. A., 1930, Fossil species of *Hastigerinella:* Cushman Lab. Foram. Research Contr., vol. 6, pp. 17–19.

——, 1946, A rich foraminiferal fauna from the Cocoa sand of Alabama: Cushman Lab. Foram. Research Spec. Pub. 16, pp. 3–40.

——, and BERMUDEZ, P., 1949, Some Cuban species of *Globorotalia:* Cushman Lab. Foram. Research Contr., vol. 25, pp. 26–45.

——, and SIMONSON, R. R., 1944, Foraminifera from the Tumey formation, Fresno County, California: Jour. Paleontology, vol. 18, pp. 186–203.

——, and STAINFORTH, R. M., 1945, The Foraminifera of the Cipero marl formation of Trinidad, British West Indies: Cushman Lab. Foram. Research Spec. Pub. 14, pp. 3–75.

——, and STONE, BENTON, 1947, An Eocene foraminiferal fauna from the Chira shale of Peru: Cushman Lab. Foram. Research Spec. Pub. 20, pp. 1–27.

STAINFORTH, R. M., 1948, Applied micropaleontology in coastal Ecuador: Jour. Paleontology, vol. 22, pp. 113–151.

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PLEISTOCENE BRACHYURA FROM THE LOS ANGELES AREA: CANCRIDAE[1]

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ABSTRACT—Five species of Pleistocene Brachyura belonging to the genus *Cancer* are figured and described from the Los Angeles area. Because of their abundance and specific nature, it is suggested that fossil appendage segments may be useful in stratigraphic paleontology.

INTRODUCTION

PLEISTOCENE crabs of the genus *Cancer* have been known from the Pacific coast and particularly from the Los Angeles area for some time, and Dr. Mary Rathbun (1926) recorded six of the nine known Recent and Pleistocene species in her monograph on the fossil stalk-eyed Crustacea of the Pacific slope of North America. Figures or adequate descriptions of the appendages and fragments commonly found fossil, however, generally are not available in either zoological or paleontological literature.

The distal elements of the chelipeds of crabs appear to resist disintegration by wave and organic action more than do the somewhat fragile carapaces and proximal articles. For this reason, and because they exhibit several specific characteristics, the dactyls and propods (movable and immovable fingers, respectively) merit consideration not hitherto given them by paleontologists. Such fragments are abundant in some ancient strata and they seem to be stratigraphically useful, but one must have considerable knowledge of these fossils and of the Recent Decapoda in general before one can identify them. Because most paleontologists lack detailed knowledge of the Recent Decapoda, the fossil crabs from the Pleistocene have been quite useless to them. It is hoped that this paper will provide a ready means of identification of fragments of Pleistocene *Cancer* from the area studied.

The fossil specimens on which this paper is based were received from the very extensive collections of Mr. George Kanakoff, Curator of Invertebrate Paleontology of the Los Angeles County Museum, to whom grateful acknowledgment is made. The study was conducted at the Allan Hancock Foundation of the University of Southern California. I am indebted to Dr. John S. Garth, Research Associate at the Foundation, for the privilege of examining the Foundation's large collections of Recent species of *Cancer*. Miss Janet Haig, Research Assistant at the Foundation, gave the writer much valuable taxonomic advice. Special thanks are due Dr. William H. Easton, Associate Professor, Department of Geology, University of Southern California, for his direction of this study.

[1] Contribution from the Allan Hancock Foundation, University of Southern California, Los Angeles, California.

THE TAXONOMIC LIMITS OF FRAGMENTS OF *Cancer*

Cancer cheliped propods and dactyls can be differentiated from many, but not from all, of the decapod groups by a combination of the following characteristics:

1. Usually large size, with a generally ovoid cross-section at the largest most proximal cutting tooth.
2. Moderate number (4 to 11) of cutting teeth.
3. Relative shortness of dactyls and propods; ratio of length to height (measured at the largest most proximal tooth) of 2 to 2.2 for propods and 2.5 to 3.5 for dactyls, at least in the species studied.
4. Fingers (tips of dactyls and propods) pointed, not spoon-shaped.

The presence of these characters excludes most of the grapsoid, portunid, oxystomatous and anomuran crabs, but probably not many of the xanthid fragments. Few species of xanthids were encountered in the strata studied and these could scarcely be con-

fused with the species of *Cancer* figured in this paper. In the writer's opinion, fragments from similar strata having the characteristics listed above are likely to be *Cancer* fragments. Others could belong to xanthid genera or to other species of *Cancer*, or they could be aberrant forms of the species herein reported.

Cancer anthonyi Rathbun, listed by Dr. Rathbun (1926, p. 7) as being a Pleistocene species, is not considered in this report because it is lacking in the collections examined by the writer.

The fossil specimens recorded here are deposited in the collection of invertebrate paleontology at the Los Angeles County Museum, Exposition Park, Los Angeles, California. The abbreviation "LACMIP" refers to this disposition of specimens.

LOCALITIES

Specimens were examined that had been collected from the following Los Angeles County Museum invertebrate paleontology localities.

Loc. 131: Pleistocene. San Pedro formation, Palos Verdes Hills, at the 500-block of North Pacific Avenue, San Pedro, California. Collector, James C. Marsh, 1937. Species represented: *Cancer branneri, C. jordani, C. productus.*

Loc. 66–1: Pleistocene. Gully No. 1, Upper Newport Bay at the northeast corner of the military air strip, about ¼ mile southwest of the salt reducing plant, Orange County, California. Collector, George Kanakoff. Species represented: *Cancer branneri, C. gracilis, C. jordani, C. magister.*

Loc. 130–7: Pleistocene. Timm's Point formation, type locality, Hole No. 7, across the street and railroad tracks from Berth 79, Los Angeles Harbor. Species represented: *Cancer branneri, C. productus.*

Loc. 142: Pleistocene. Second and Orizaba Streets, San Pedro, California. Collector, Dr. A. T. Tieje, 1915–1916. Species represented: *Cancer branneri, C. jordani.*

SYSTEMATIC PALEONTOLOGY

Phylum ARTHROPODA
Class CRUSTACEA
Order DECAPODA
Family CANCRIDAE Alcock
CANCER GRACILIS Dana
Text-figures 1, 10

Cancer gracilis DANA, 1852, Acad. Nat. Sci. Philadelphia Proc., vol. 6, p. 73; RATHBUN, 1926, U. S. Nat. Mus. Bull. 138, p. 65; —, 1930, idem, Bull. 152, pp. 219–222 (contains prior synonymy).

Description of cheliped parts.—Dactyl: laterally compressed, very high and oval in cross-section. Superior surface with a single marginal row of sharp irregular spines. Lateral and medial surfaces covered with small tubercules. Setiferous pits scattered over lateral surface but tending to be in rows. Teeth about six, the most proximal (first) of which has three apical teeth; third tooth smaller than second and fourth; fifth smaller than fourth and sixth. Propod: teeth about six, triangulate and laterally compressed. Lateral and medial areas covered with tubercules. Lateral surface with setiferous pits scattered but tending to be in rows.

Modern ecology.—Shallow water bay localities having a sandy bottom.

Bathymetric range: intertidal to 56 fathoms (Rathbun, 1930, p. 222). Geographic range: Prince of Wales Island, Alaska, to Playa Maria Bay, Lower California, Mexico (Rathbun, 1930, p. 222)

C. gracilis is abundant enough north of Point Conception, California, to be of commercial value; south of that point it appears to be relatively uncommon. It occurs in fairly shallow water on sandy bottoms and is often taken from localities where *Cancer magister* is abundant.

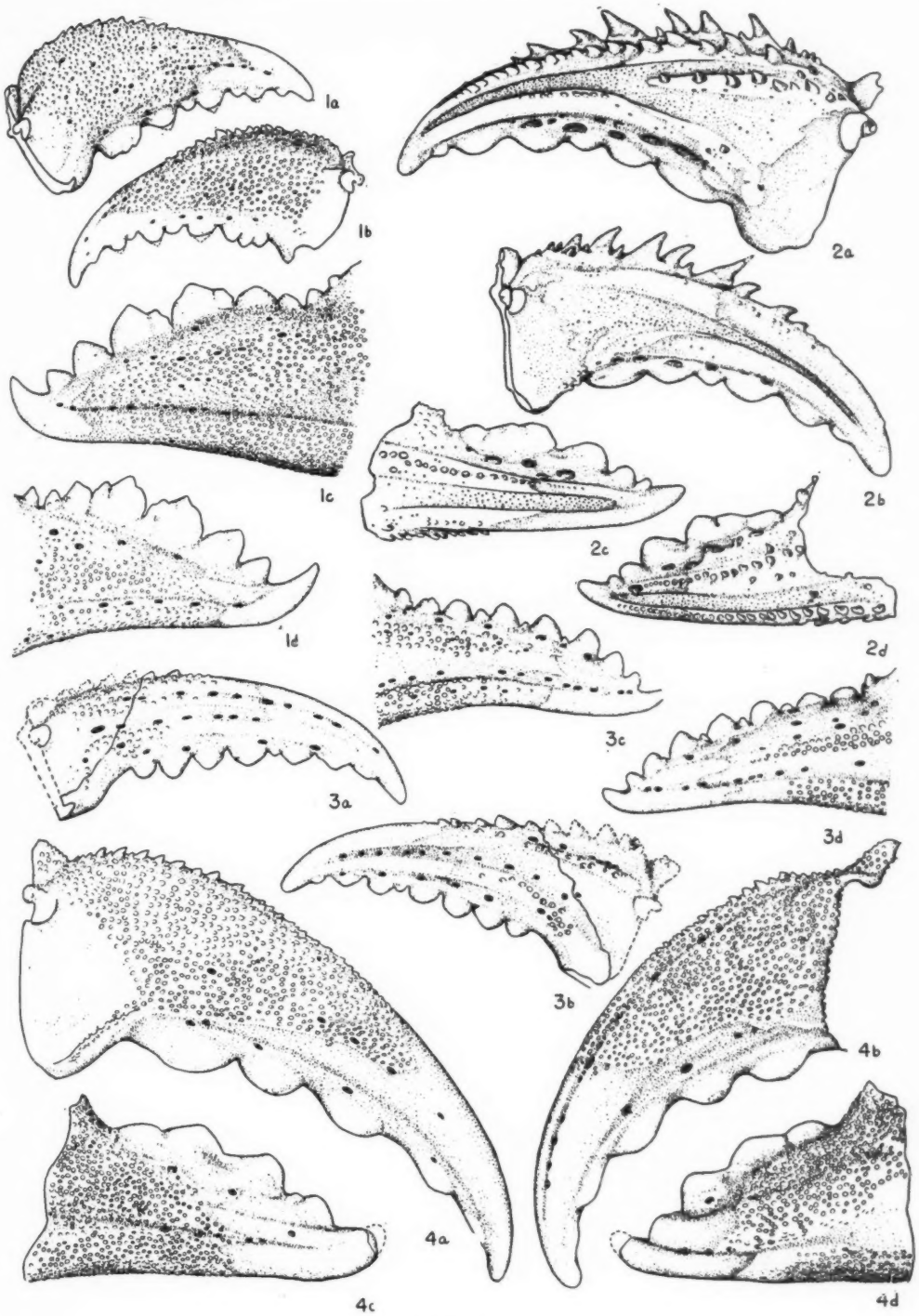
Stratigraphic range.—Pleistocene to Re-

FIG. *1*—*Cancer gracilis* Dana. ×3.3. *a*. Dactyl, medial surface; *b*, dactyl, lateral surface; *c*, propod, lateral surface (Recent specimen); *d*, propod, medial surface (Recent specimen). LACMIP 66-1.

FIG. *2*—*Cancer branneri* Rathbun. ×3.3. *a*, Dactyl, lateral surface; *b*, dactyl, medial surface; *c*, propod medial surface; *d*, propod, lateral surface. LACMIP 130–7.

FIG. *3*—*Cancer magister* Dana. ×3.3. *a*, Dactyl, lateral surface (composite of fossil and Recent specimen); *b*, dactyl, medial surface (composite of fossil and Recent specimen); *c*, propod, lateral surface (Recent specimen); *d*, propod, medial surface (Recent specimen). LACMIP 66–1.

FIG. *4*—*Cancer productus* Randall. ×3. *a*, Dactyl, medial surface; *b*, dactyl, lateral surface; *c*, propod medial surface; *d*, propod, lateral surface. LACMIP 130–7.



FIGS. 1–4

cent. California: Santa Monica, San Pedro, San Diego (Rathbun, 1926, p. 65).

Locality.—LACMIP No. 66–1, eight dactyls (one hypotype), one propod.

CANCER MAGISTER Dana
Text-figures 3, 9

Cancer magister DANA, 1852, Acad. Nat. Sci. Philadelphia Proc., vol. 6, p. 73; RATHBUN, 1926, U. S. Nat. Mus. Bull. 138, pp. 64–65; ——, 1930, idem, Bull. 152, pp. 222–226 (contains prior synonymy).

Description of cheliped parts.—Dactyl: reniform in cross-section. Superior surface with a conspicuous row of fairly large, often spinulate, spines. Lateral and medial surfaces covered with tubercules and having low, tuberculate or spinulate ridges. Setiferous pits generally confined to rows in depressed areas between low ridges. Teeth about eight. Tips of fingers usually white. Propod: teeth about ten. Setiferous pits generally confined to sunken areas. Lateral and medial surfaces with elevated tuberculate ridges.

Modern ecology.—Shallow water; bay or offshore fauna.

Bathymetric range: intertidal to 50 fathoms (Rathbun, 1930, p. 223). Geographic range: Unalaska to Monterey Bay, California (Rathbun, 1930, p. 223). The literature indicates that this species favors a fine gray sand bottom.

Stratigraphic range.—Pleistocene to Recent. California: San Pedro (Rathbun, 1926, p. 64), Newport Bay.

Locality.—LACMIP No. 66–1, three dactyls (one hypotype).

CANCER PRODUCTUS Randall
Text-figures 4, 8

Cancer productus RANDALL, 1839, Acad. Nat. Sci. Philadelphia Jour., vol. 8, pt. 1, p. 116; RATHBUN, 1926, U. S. Nat. Mus. Bull. 138, p. 62; ——, 1930, idem, Bull. 152, pp. 203–205 (contains prior synonymy).

Description of cheliped parts.—Dactyl: ovoid in cross-section. Superior area with numerous small spines which are largest near the superior medial margin. Lateral and medial areas tuberculate, but lacking sulci or elevated areas. Setiferous pits present, no setiferous sulci. Teeth about five. Tips of fingers black. Propod: teeth about four. Lateral and medial surfaces tuberculate; longitudinal grooves fairly prominent. Setiferous pits present; tend to be arranged in longitudinal rows.

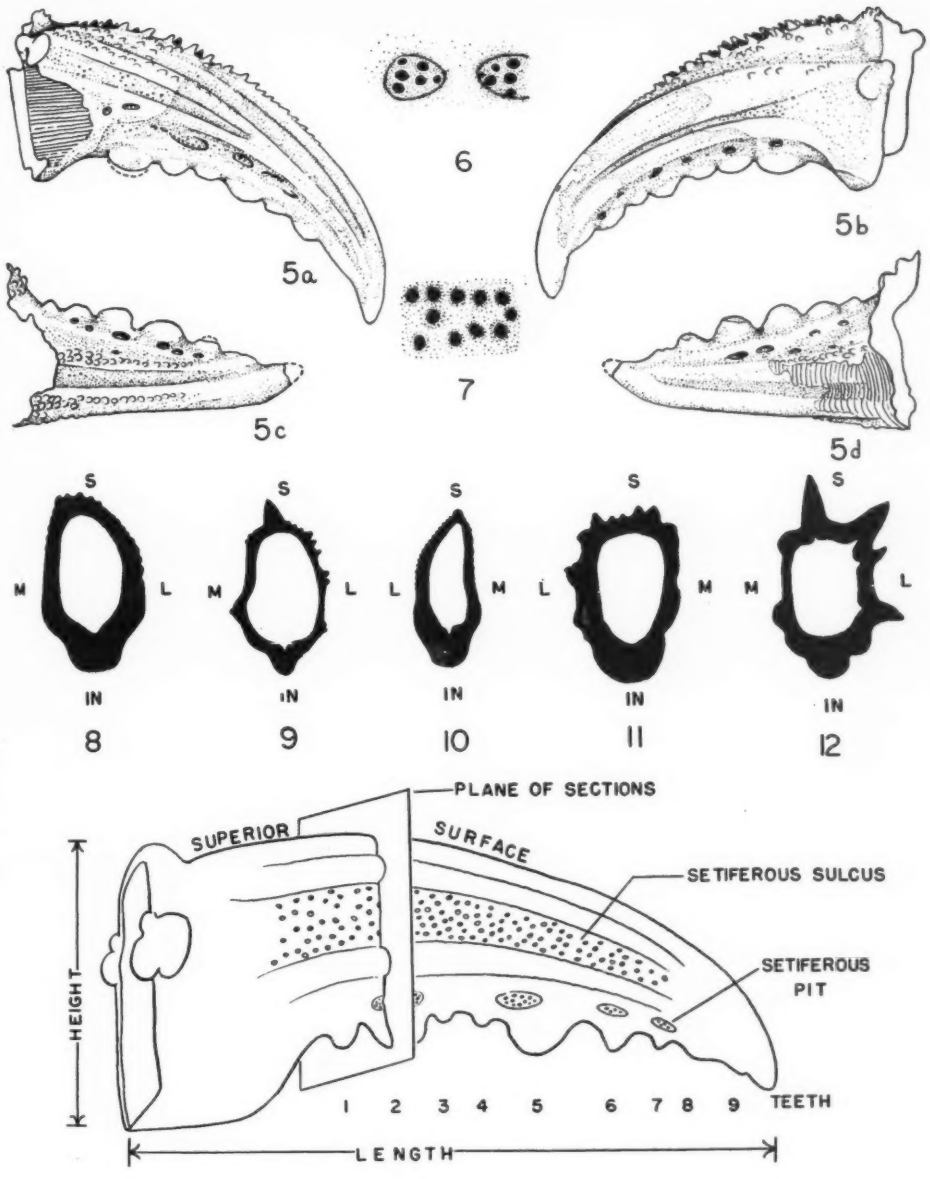
Modern ecology.—Shallow bay or offshore water.

Bathymetric range: intertidal to 43 fathoms (Rathbun, 1930, p. 207). Geographic range: Alaska to Laguna Beach, California (Rathbun, 1930, p. 205). Like *C. magister*, this species appears to be most abundant at localities north of Monterey Bay, California. A sand or mud-sand bottom appears to be favored by this species.

Stratigraphic range.—Pliocene to Recent. California: Santa Barbara, San Pedro (Rathbun, 1926, p. 62), Timm's Point, San Pedro.

Localities.—LACMIP No. 131, three dactyls; No. 130–7, one dactyl, one partial cheliped (hypotype).

FIG. *5*—*Cancer jordani* Rathbun. ×5. *a*, Dactyl, lateral surface; *b*, dactyl, medial surface; *c*, propod, lateral surface; *d*, propod, medial surface. LACMIP 142.
FIG. *6*—*Cancer branneri* Rathbun. Setiferous pits of lateral surface, highly magnified.
FIG. *7*—*Cancer branneri* Rathbun. Magnification of large lateral sulcus showing the many minute perforations.
FIG. *8*—*Cancer productus* Randall. Semi-diagrammatic cross-section of dactyl at proximal tooth. *S* = superior surface, *L* = lateral surface, *M* = medial surface, *IN* = inferior surface.
FIG. *9*—*Cancer magister* Dana. Semi-diagrammatic cross-section of dactyl at proximal tooth.
FIG. *10*—*Cancer gracilis* Dana. Semi-diagrammatic cross-section of dactyl at proximal tooth.
FIG. *11*—*Cancer jordani* Rathbun. Semi-diagrammatic cross-section of dactyl at proximal tooth.
FIG. *12*—*Cancer branneri* Rathbun. Semi-diagrammatic cross-section of dactyl at proximal tooth.
FIG. *13*—Diagram of dactyl illustrating morphological terms used in this paper.



FIGS. 5–13

CANCER JORDANI Rathbun
Text-figures 5, 11

Cancer jordani RATHBUN, 1900, Am. Naturalist, vol. 34, p. 133; ——, 1926, U. S. Nat. Mus. Bull. 138, p. 64; ——, 1930, idem, Bull. 152, pp. 215–217 (contains prior synonymy).

Description of cheliped parts.—Dactyl: almost hexagonal in cross-section. Superior surface with several rows of small spines. Lateral and medial surfaces lacking setiferous pits except above teeth but having conspicuous setiferous sulci. Teeth about seven. Propod: teeth about five. Lateral area with a deep sulcus bordered by elevated spinulate

ridges. The dactyls and propods of this species in general resemble those of *C. branneri* considerably. These species differ primarily only in the more numerous and smaller spines present on specimens of *C. jordani.*

Remarks.—The average ratio of the carapace width to the dactyl length of three Recent specimens is about 4.7. The largest fossil dactyl in the collections is 11 mm. in length. If the above ratio holds true for large crabs this indicates an individual having a carapace width of about 51.7 mm., which is considerably larger than any Recent specimens thus far recorded. This accords with Miss Rathbun's statement (1926, p. 64), "These fingers (Pleistocene, Nob Hill, Lower San Pedro formation) are of unusual size indicating that the species was much larger in the Pleistocene than now."

Modern ecology.—Shallow bay or offshore water.

Bathymetric range: intertidal to 24 fathoms (Rathbun, 1930, p. 216). Geographic range: Humboldt Bay, California, to San Geronimo Island, Lower California, Mexico. This species occurs on bottoms ranging from fine sand to rocky sand and it has been taken frequently from kelp holdfasts. Most of the records of this species are from localities off San Pedro, California.

Stratigraphic range.—Pleistocene to Recent. California: San Pedro, San Diego (Rathbun, 1926, p. 64), Newport Bay.

Localities.—LACMIP No. 131, two dactyls; No. 66–1, 16 dactyls; No. 142, 34 dactyls (one hypotype), two propodi (one hypotype).

CANCER BRANNERI Rathbun
Text-figures 2, 6, 7, 12

Cancer branneri RATHBUN, 1926, U. S. Nat. Mus. Bull. 138, p. 63, pl. 16, fig. 4: ——, 1930, idem, Bull. 152, pp. 211–215 (contains prior synonymy).

Description of cheliped parts.—Dactyl: almost hexagonal in cross-section. Superior surface with a medial and lateral row of large spines. Lateral surface with two rows of large spines. Lateral and medial surfaces lack setiferous pits except above teeth but have large setiferous sulci. These are perforated by numerous holes which represent the setae attachment points on Recent specimens. Teeth about six. Propod: about four teeth. Lateral and medial areas with setiferous sulci and ridges bearing fairly large spines.

Modern ecology.—Shallow offshore water with sand or sand-mud bottom.

Bathymetric range: intertidal to 40 fathoms (Rathbun, 1930, pp. 214–125). Geographic range: Alaska to Santa Catalina Island, California (Rathbun, 1926, p. 64). This species is known mostly from localities north of the Farallone Islands, California, and usually occurs on a sandy bottom.

Stratigraphic range.—Pleistocene to Recent. California: San Pedro (Rathbun, 1926, pp. 63–64), Upper Newport Bay, Timm's Point.

Localities.—LACMIP No. 131, one dactyl, one propod; No. 66–1, nine dactyls; No. 130–7, four dactyls (one hypotype), one propod (hypotype); No. 142, one cheliped, dactyl lacking.

REFERENCES

DANA, J. D., 1852, Conspectus crustaceorum etc., Conspectus of the Crustacea of the exploring expedition under Capt. Wilkes, U.S.N., including the Crustacea Cancroidae Corystoidea: Acad. Nat. Sci. Philadelphia Proc., vol. 6, pp. 73–91.

RANDALL, J. W., 1839, Catalogue of the Crustacea brought by Thomas Nuttall and J. K. Townsend, from the west coast of North America and the Sandwich Islands: Acad. Nat. Sci. Philadelphia Jour., vol. 8, pt. 1, pp. 106–147.

RATHBUN, M. J., 1900, Synopses of North American invertebrates, VII, The Cyclometopous or Cancroid crabs of North America: Am. Naturalist, vol. 34, pp. 131–143.

——, 1926, The fossil stalk-eyed Crustacea of the Pacific slope of North America: U. S. Nat. Mus. Bull. 138.

——, 1930, The Cancroid crabs of America of the families Euryalidae, Portunidae, Atelecyclidae, Cancridae and Xanthidae: U. S. Nat. Mus. Bull. 152.

JOURNAL OF PALEONTOLOGY, VOL. 25, NO. 2, PP. 171–186, PLS. 29–33, 3 TEXT FIGURES, MARCH 1951

CORALS FROM THE BRAZER FORMATION (MISSISSIPPIAN) OF NORTHERN UTAH

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ABSTRACT—Three new genera and eight new species of corals from the Brazer limestone of northern Utah are described. Five coral zones are recognized in the Brazer limestone, each characterized by one or more of the new species described in this paper, or by other genera and species herein illustrated. An evolutionary sequence for the new corals is described, based principally on morphologic comparison of adult growth stages and on stratigraphic order of occurrence.

INTRODUCTION

THE Brazer limestone, Mississippian, of Utah and southeastern Idaho has long been known to contain an abundant tetracoral fauna. Most published faunal lists of the Brazer limestone (Girty in Mansfield, 1927, pp. 68–70; Richardson, 1941, pp. 23–24; Williams, 1943, p. 596; and Williams and Yolton, 1945, pp. 1145–1151) merely include "large horn corals," "zaphrentid corals," or refer the solitary corals to one of several imperfectly understood species of *Zaphrentis*, as described by Hall (in Stansbury, 1855, p. 408), and Meek (1877, pp. 52–54). These corals, however, do not belong to *Zaphrentis* (sensu stricto) as restricted by Schindewolf (1938, p. 452); nor do they belong to the various genera proposed for Carboniferous "zaphrentid" corals, *Zaphrentoides* Stuckenberg, 1895; *Triplophyllum* Simpson, 1900; and *Triplophyllites* Easton, 1944.

The species described by Hall and by Meek, *Zaphrentis ? multilamellata*[1] Hall, *Z. stansburii* Hall, and *Z. excentrica* Meek, were based on poorly preserved and fragmentary specimens, without adequate description of stratigraphic or geologic occurrence. The specific descriptions were not based on polished or thin sections, but on external characteristics and fracture surfaces—hence they are not adequate from a modern point of view.

The writer obtained the "cotypes" and "plesiotypes" of these species on loan from the United States National Museum. None of the specimens had ever been sectioned, and the National Museum is not adequately equipped for coral sectioning at the present time. Consequently, the diagnostic internal characteristics of these species remain unknown. The "cotypes" and "plesiotypes" for each species appear to contain more than one species, and possibly more than one genus. Because of the unknown nature of Hall's and Meek's species, the writer has named new species from the well preserved specimens in his collections. When the types of Hall's and Meek's species are sectioned, their relationship to the species described in this paper can be determined, and their species names given priority if necessary.

Two nearly complete sections of the Brazer limestone were studied and collected in detail to furnish the material for this study. Several hundred specimens of corals were obtained from many different stratigraphic levels in the Brazer limestone. Of these, only about one hundred were thin sectioned with an average of three thin sections per specimen, and the remainder of the specimens were identified from polished sections.

Both of the stratigraphic sections are located in Cache County, northern Utah (fig. 1). One section, bounded by the Madison limestone, Lower Mississippian, below, and the Wells formation, Pennsylvanian,

[1] *Z. ? multilamella*, as commonly cited, is not the original correct name for that species. Apparently there was an accident to the printer's type, and the final "ta" was mashed off. In the original reference (Hall in Stansbury, 1855, p. 408), there are two unexplained gaps after the name as commonly cited, and in the index at the back of the book, it is "*multilamellata*." In some copies of the original reference, part of the missing "t" is showing. (Easton, personal communication).

above, is located in Leatham Hollow (S. ½ sec. 28, T. 11 N., R. 2 E.) in the Bear River Range about 8 miles southeast of Logan. The other section, with the lower portion of the Brazer unexposed and the upper contact

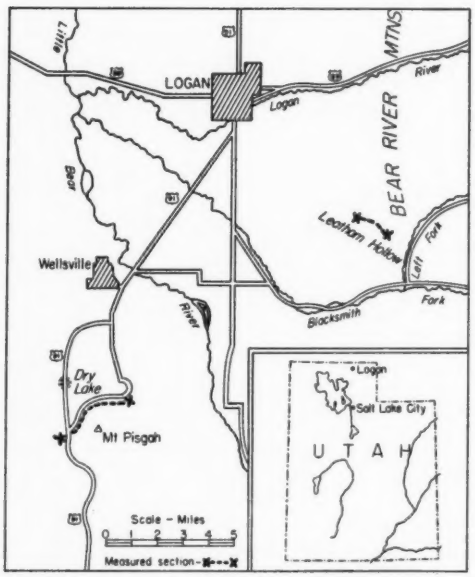


FIG. *1*—Sketch map of area near Logan, Utah, showing location of Dry Lake and Leatham Hollow sections.

with the Wells poorly exposed, is located near Dry Lake (E. ½ sec. 33, T. 10 N., R. 1 W.) in the Pisgah Hills, about 12 miles south-southwest of Logan. The Bear River Range and the Pisgah Hills are northward extensions of the Wasatch Range.

The corals were collected bed by bed, and their stratigraphic positions accurately recorded in the field on detailed stratigraphic sections measured and described at the same time. The specimens were cut with a diamond saw transversely at selected points in the mature growth stage, and in youth stages if present, and longitudinally perpendicular to the counter-cardinal plane. Thin sections were then prepared to show the intricate internal structural details most clearly. The thin sections were photographed with transmitted light with a 4×5 inch plate camera on process film. Enlargements were printed at a magnification of four times natural size for most of the corals, and these unretouched photographs were used in the preparation of the plates.

The use of retouched or inked and bleached photographs of polished sections taken by reflected light in the study and illustration of corals is undesirable. This procedure not only allows personal errors in interpreting the photographs, but also fails to reveal the details of structure of the dissepiments and tabulae. This is especially apparent if the coral and its matrix rock are both dark in color, as is the case with the Brazer corals. Cellulose peels of polished and acid-etched sections are of some value, but did not yield satisfactory results with the corals used in this study.

The generic and specific descriptions of these corals are based principally upon ephebic (adult or mature) characteristics, because of the poor preservation and general absence of the younger growth stages in the specimens studied.

The coral terminology used in this paper is essentially that of Easton (1944, pp. 15–25), Hill (1935, pp. 481–519), and Sanford (1939, pp. 303–313).

The holotypes and paratypes of the new species are deposited in the United States National Museum.

The writer wishes to express his thanks to

EXPLANATION OF PLATE 29

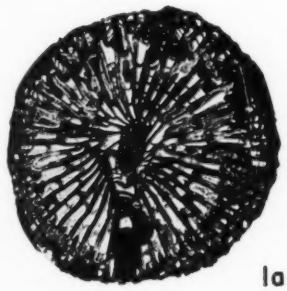
FIGS. *1a, b, 3—Ekvasophyllum inclinatum* Parks, n. sp. *1a, b*, Holotype, USNM 115997; *a*, transverse section, middle ephebic stage, ×2; *b*, longitudinal section, ×2; *3*, transverse section of another specimen, ephebic stage, ×2. (p. 175)

2a, b—Lithostrotionella sp. *a*, Transverse section, ×2; *b*, longitudinal section of one corallite, ×2. (p. 180)

4, 5—Triplophyllites cf. *T. palmatus* Easton. *4*, Transverse section, ephebic stage, ×2; *5*, transverse section of another specimen, ephebic stage, ×2. (p. 181)

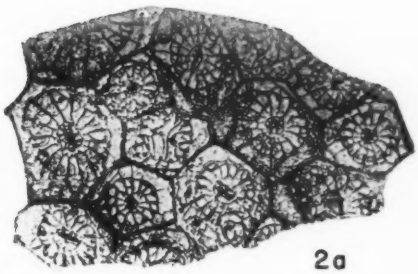
6a, b—Caninia sp. A. *a*, Transverse section, ephebic stage, ×1; *b*, longitudinal section, ×1. (p. 181)

7a, b—Caninia sp. B. *a*, Transverse section, ephebic stage, ×2; *b*, longitudinal section, ×2. (p. 182)



1a

2b



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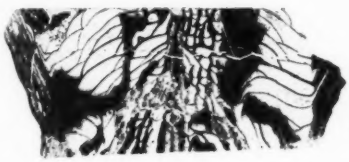

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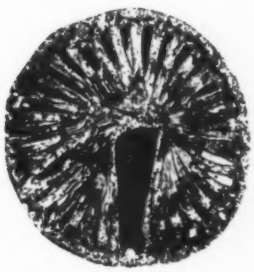

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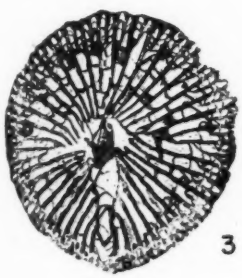

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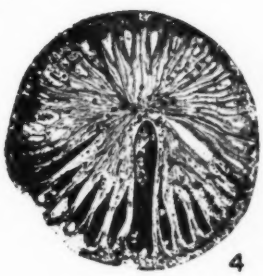

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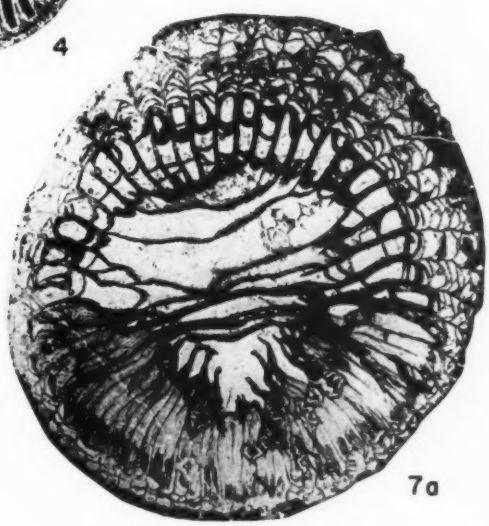

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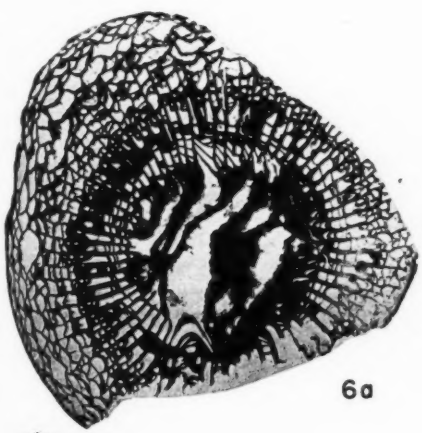

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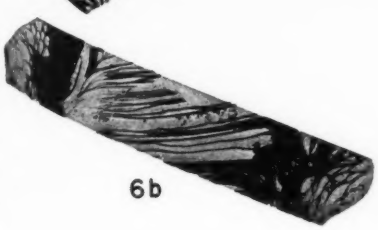
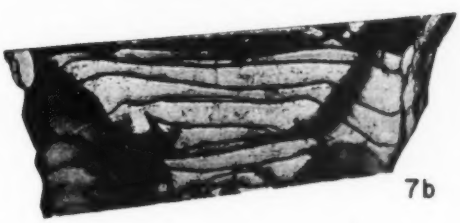
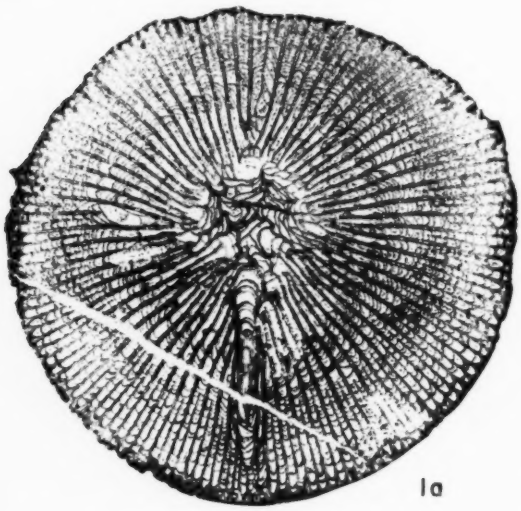


6b



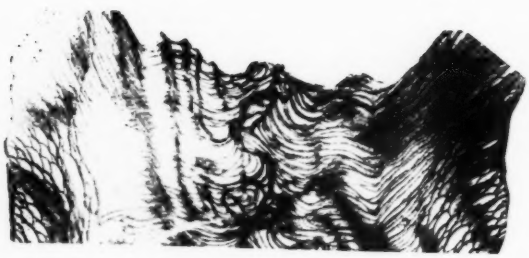
7b

Parks, Upper Mississippian corals from Utah



1a

2a



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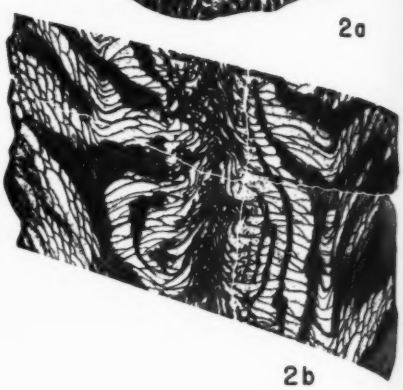

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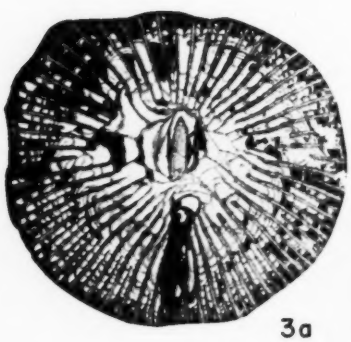

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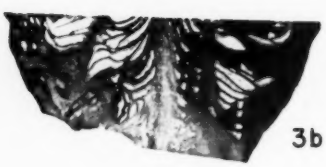


3b

Parks, Upper Mississippian corals from Utah

Dr. L. R. Laudon, University of Wisconsin, who discussed the stratigraphy with the writer in the field, and gave advice during the preparation of this report. Particular thanks are due to F. D. Holland, Jr., University of Cincinnati, the writer's partner in the field, who worked on the stratigraphy of the Madison limestone in the same area. Thanks are also due to Dr. W. H. Easton, University of Southern California, who read the preliminary manuscript, and gave advice on some of the taxonomic problems involved.

STRATIGRAPHY

The Brazer limestone was named by Richardson (1913, p. 413) from exposures in Brazer Canyon, Crawford Mountains, Utah, about 35 miles east of Logan. Williams (1943, p. 610) has redescribed the Brazer of the type locality and has shown that neither the top nor the bottom of the formation is exposed in Brazer Canyon.

The general stratigraphic sequence of the two sections is shown in figure 2. At Leatham Hollow the Brazer formation lies directly on the Madison limestone with no evidence of angular discordance. The Brazer formation, bounded by the Madison limestone below and the Wells formation above, is approximately 2240 feet thick here. The presence of *Pseudostaffella* sp. indicates a Pennsylvanian age for the limestone (Wells) at the top of the measured section. The lower 950 feet of the Brazer is composed of sandstone, siltstone and arenaceous limestone. The upper 1290 feet is composed of well exposed, grayish-black, fine-grained limestone, containing an abundance of solitary and compound corals.

Near Dry Lake the basal arenaceous members and an undetermined thickness of the limestones are buried beneath the valley floor. Over 2000 feet of limestone is exposed there, forming a considerably thicker section of limestone than that at Leatham Hollow, 12 miles to the northeast. The lower 1000 feet consists of thin-bedded, grayish-black, fine-grained limestone, rhythmically interbedded with soft, dark gray, silty limestone and pale red to pale purple, silty limestone and shale. Overlying this is 970 feet of thick-bedded, grayish-black, fine-grained limestone containing many nodules, lenses, and layers of banded gray chert, and black or brown chert. The top of the measured section, exposed in a saddle at the crest of the Pisgah Hills, is composed of purplish-gray silty limestones. The Wells formation is exposed a few hundred yards to the northeast; however, as a result of the poor exposures in the saddle, the contact of the Brazer with the Wells was not observed.

SYSTEMATIC PALEONTOLOGY

The corals described in this paper are provisionally assigned to the family Clisiophyllidae. They bear no close relationship to any other family, and yet they are not at all typical of the clisiophyllids. The Brazer corals most closely resemble *Cyathoclisia* Dingwall 1926, in their most distinctive feature, the curvature of the septa about the cardinal fossula, although the curvature is more pronounced in the Brazer corals. Dingwall did not assign *Cyathoclisia* to any family, although she compared it with both *Clisiophyllum* and *Paleosmilia* (1926, p. 14). Hill (1935, p. 54) doubtfully referred *Cyathoclisia* Dingwall to the family Clisiophyllidae, but remarked that the curvature of the septa about the cardinal fossula was a wide departure from the typical structure of that family.

EXPLANATION OF PLATE 30

All figures ×2

FIGS. *1a, b, 2a, b, 4—Faberophyllum araneosum* Parks, n. sp. *1a, b*, Holotype, USNM 116004; *a*, transverse section, ephebic stage; *b*, longitudinal section. *2a, b*, Paratype, USNM 116005; *a*, transverse section, late ephebic stage, slightly above floor of calyx; *b* longitudinal section. *4*, Transverse section of another specimen, ephebic stage. (p. 178)

3a, b—Ekvasophyllum turbineum Parks, n. sp. Holotype, USNM 115998; *a*, transverse section, ephebic stage; *b*, longitudinal section. (p. 175)

5—Triplophyllites sp. A. Transverse section, ephebic stage. (p. 181)

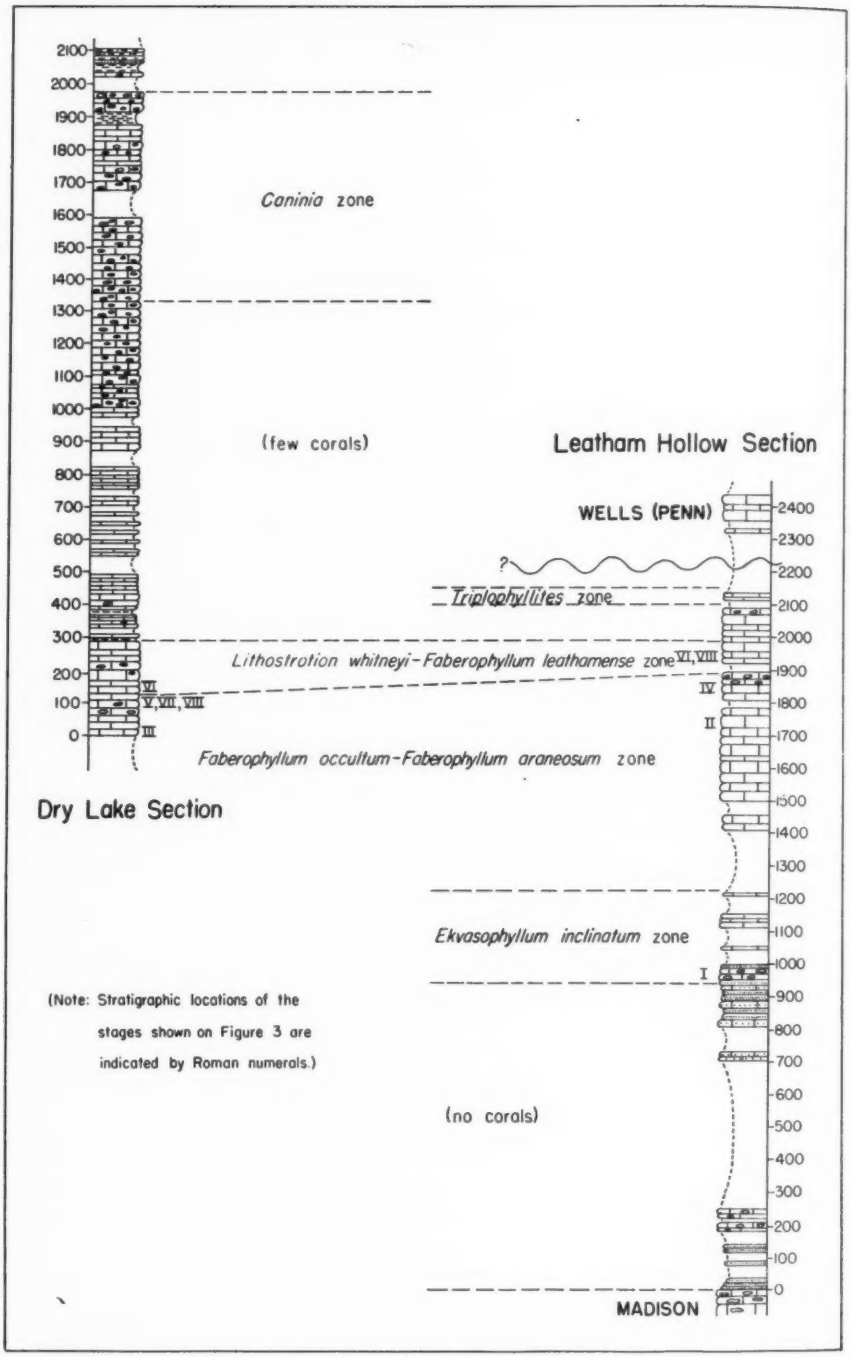


FIG. 2—Diagrammatic stratigraphic sections of Brazer formation at Dry Lake and Leatham Hollow near Logan, Utah, showing coral zonation and correlation between the two sections.

Phylum COELENTERATA
Class ANTHOZOA
Order TETRACORALLA
Family CLISIOPHYLLIDAE ?
Genus EKVASOPHYLLUM Parks, n. gen.

Diagnosis.—Solitary, slightly curved, trochoid, medium sized corals, with numerous septa tending towards radial symmetry except near the prominent cardinal fossula where they are pinnately arranged; solid, slightly laterally compressed, rod-like columella; incomplete tabulae arch upwards to join the columella; dissepiments present; cardinal fossula on convex side.

Genotype.—*Ekvasophyllum inclinatum* Parks, n. sp.

Occurrence.—*Ekvasophyllum inclinatum* zone and *Faberophyllum occultum—F. araneosum* zone, Brazer limestone, Leatham Hollow, Wasatch Mountains, Utah.

Remarks.—This genus most closely resembles *Lophophyllum* Edwards & Haime 1850. However, the type specimen of *Lophophyllum* has probably been lost (Hill, 1939, p. 86), and apparently was never sectioned, so that the internal characteristics of the genus are not well known. The columella of *Ekvasophyllum* is not connected to the cardinal septum, as it is supposed to be in *Lophophyllum*, but may or may not be attached to the counter septum.

Ekvasophyllum differs from *Koninckophyllum* Thomson & Nicholson 1876, in the possession of a thicker columella, and in the pinnate arrangement of the septa in the cardinal quadrants, and in the unusually prominent cardinal fossula.

EKVASOPHYLLUM INCLINATUM Parks, n. sp.
Plate 29, figures 1a, b, 3

Diagnosis.—Medium sized corals, with 42 to 46 major septa in ephebic stage, some of which reach to axis, minor septa of one-fourth radius length; dissepiments present; slightly laterally compressed columella; tabulae slightly inclined upward toward axis, and join columella at a large angle.

Externals.—All the specimens studied were completely enclosed in dense, fine-grained limestone. Calyx not observed. Cardinal fossula on side of convex curvature.

Transverse sections.—In ephebic stage, dissepimentarium occupies about one-fourth of radius; dissepiments small, concentric. Septa approach radial symmetry except near cardinal fossula where they are pinnately arranged; 42 to 46 major septa at 18 to 20 mm. diameter; most do not reach axis, all slightly dilated. Tabular intersections present. Cardinal fossula prominent, bounded by fused axial ends of adjoining pinnate major septa. Solid, slightly laterally compressed, rod-like columella, not attached to cardinal septum, but may be connected to counter septum. Cardinal septum short; counter and alar septa equal in length to adjacent major septa.

Longitudinal sections.—Dissepiments small, elongate, steeply inclined. Tabulae incomplete, slightly upturned at margins, slope upward toward axis where they join the solid, rod-like columella at a large angle.

Material.—Specimens studied, 11. Holotype, USNM 115997.

Occurrence.—*Ekvasophyllum inclinatum* zone, Brazer limestone, Leatham Hollow, Wasatch Mountains, Utah.

Remarks.—This form may be conspecific with *Lophophyllum? cascadense* Warren (1927, p. 44, pl. 3, fig. 1), but that species was not described or figured adequately for a close comparison. The two forms are probably congeneric.

Ekvasophyllum inclinatum differs from *E. turbineum* in its smaller size, smaller number of septa, less steeply inclined tabulae, and less laterally compressed columella.

EKVASOPHYLLUM TURBINEUM Parks, n. sp.
Plate 30, figures 3a, b

Diagnosis.—Medium sized corals with 50 to 56 major septa in ephebic stage, minor septa half as long as major septa; wide dissepimentarium; extremely laterally compressed columella; tabulae very steeply inclined upward near axis, and merge smoothly into columella at a small angle.

Externals.—All the specimens studied were completely enclosed in dense, fine-grained limestone. Epitheca commonly eroded away. Columella projects above floor of calyx. Cardinal fossula on side of convex curvature.

Transverse sections.—In ephebic stage, epitheca and outer portion of dissepimentarium commonly eroded away. Dissepimentarium occupies nearly one-half of

radius; dissepiments small, concentric. Septa approach radial symmetry except near prominent cardinal fossula where they are pinnately arranged; 50 to 56 major septa at 24 to 26 mm. diameters, major septa about three-fourths radius long, do not reach axis. Minor septa half as long as major septa. Tabular intersections numerous. Cardinal fossula prominent, bounded by fused axial ends of adjoining pinnate major septa. Solid, extremely laterally compressed, rod-like columella, not continuous with either cardinal or counter septa. Cardinal septum short, counter and alar septa equal in length to adjacent major septa.

Longitudinal sections.—Epitheca and outer portions of dissepimentarium commonly eroded away. Dissepiments elongate, steeply inclined. Tabulae incomplete, turned up at margins, recurve and slope steeply upward at axis where they merge at a low angle into the solid, rod-like columella.

Material.—Specimens studied, 5. Holotype, USNM 115998.

Occurrence.—*Faberophyllum occultum—F. araneosum* zone, Brazer limestone, Leatham Hollow, Wasatch Mountains, Utah.

Remarks.—This species differs from *E. inclinatum* in its consistently larger size, consistently larger number of septa, wider dissepimentarium, more steeply inclined tabulae, and more laterally compressed columella. The two species are morphologically distinct and stratigraphically separated. No specimens of either species were well enough preserved in the youth stages for ontogenetic comparison, which might have proved an evolutionary relationship.

Genus TURBOPHYLLUM Parks, n. gen.

Diagnosis.—Solitary, moderately large, slightly curved, trochoid to subcylindrical corals, with numerous septa tending toward radial symmetry except near the prominent cardinal fossula where they are pinnately arranged; wide dissepimentarium; incomplete tent-shaped tabulae form an acrocolumella, no solid, rod-like columella; cardinal fossula on convex side.

Genotype.—*Turbophyllum multiconum* Parks, n. sp

Occurrence.—*Faberophyllum occultum—F. araneosum* zone, Brazer limestone, Dry Lake, Wasatch Mountains, Utah.

Remarks.—This genus resembles *Koninckophyllum* Thomson & Nicholson 1876, but differs from it in the nature of the cardinal fossula: *Koninckophyllum* has a typical clisiophyllid fossula bounded by straight septa and *Turbophyllum* has a prominent closed fossula bounded by the fused axial ends of the adjoining pinnate major septa. *Turbophyllum* differs from *Ekvasophyllum* in lacking a solid, rod-like columella, and in possessing tent-shaped tabulae which form an acrocolumella.

TURBOPHYLLUM MULTICONUM Parks, n. sp.
Plate 31, figures 2a, b, 3a, b

Diagnosis.—Moderately large corals, with 56 to 72 major septa, minor septa half as long as major septa; wide dissepimentarium; tent-shaped tabulae form an acrocolumella; no solid, rod-like columella.

Externals.—Moderately curved, trochoid to subcylindrical. Moderately strong interseptal ridges and septal grooves. Calyx deep. Cardinal fossula on side of convex curvature.

Transverse sections.—In ephebic stage, dissepimentarium occupies one-third to one-half radius; dissepiments small, concentric. Septa approach radial symmetry except near cardinal fossula where they are pinnately arranged; 56 to 72 major septa at 27 to 28 mm. diameters. Minor septa one-third to one-half as long as major septa. Tabular intersections numerous only near axis. Cardinal fossula prominent, bounded by fused axial ends of adjoining pinnate major septa. Acrocolumella composed of nesting tent-shaped tabulae. Cardinal septum short, counter septum shorter than adjacent major septa, alar septa about equal in length to adjacent major septa.

Longitudinal sections.—Dissepimentarium occupies one-third to one-half of radius; dissepiments small, steeply inclined. Tabulae incomplete, upturned at margins near juncture with dissepiments, recurve and turn upwards near axis, appearing as nesting cones to form acrocolumella. No solid columella.

Material.—Specimens studied, 7. Holotype, USNM 115999; paratype, USNM 116000.

Occurrence.—*Faberophyllum occultum—F. araneosum* zone, Brazer limestone, Dry Lake, Wasatch Mountains, Utah.

Remarks.—This species is similar to *Ekvasophyllum turbineum*, but is larger, has more major septa, has a wider and denser dissepimentarium, and lacks a solid, rod-like columella.

Genus FABEROPHYLLUM Parks, n. gen.

Diagnosis.—Solitary, large, moderately curved, trochoid to subcylindrical corals, with numerous septa tending toward radial symmetry except near the prominent closed cardinal fossula where they are pinnately arranged; dissepimentarium wide; tabulae incomplete; axial structure varying among species from a complex of one or more lamellae and tabellae, to no axial structure and sagging tabulae.

Genotype.—*Faberophyllum occultum* Parks, n. sp.

Occurrence.—*Faberophyllum occultum*—*F. araneosum* zone, and *Lithostrotion whitneyi*—*Faberophyllum leathamense* zone, Brazer limestone, Leatham Hollow and Dry Lake, Wasatch Mountains, Utah.

Remarks.—This genus differs from *Dibunophyllum* Thomson & Nicholson 1876; *Clisiophyllum* Dana 1846; *Carcinophyllum* Thomson & Nicholson 1876; and *Koninckophyllum* Thomson & Nicholson 1876 principally in the prominent closed cardinal fossula with the pinnate arrangement of the septa in the cardinal quadrants. *Faberophyllum* resembles *Bothrophyllum* Trautschold 1879, in possessing pinnate septa in the cardinal quadrants; but in *Bothrophyllum* this characteristic disappears after the young stages, and in *Faberophyllum* it persists through the adult stages.

Faberophyllum differs from *Caninia* Michelin 1840; *Siphonophyllia* Scouler 1844; and *Caninophyllum* Lewis 1929 in possessing incomplete tabulae with upturned margins, and in its prominent closed cardinal fossula. *Caninia*, *Siphonophyllia*, and *Caninophyllum* have generally complete tabulae with downturned margins, and an open caniniid cardinal fossula.

Faberophyllum differs from *Vesiculophyllum* Easton 1944 in the prominent closed cardinal fossula, in not developing lonsdaleoid dissepiments, and in the less prominent dilation of major septa.

Faberophyllum resembles *Cyathoclisia* Dingwall 1926 in the manner in which the septa curve towards the cardinal fossula, but this condition is more pronounced in *Faberophyllum* in which the axial ends of the pinnate septa are fused into the fossular wall. *Cyathoclisia* also has a larger and more uniform axial complex than any of the species of *Faberophyllum*.

Faberophyllum differs from *Ekvasophyllum* and *Turbophyllum* in its generally larger size, generally larger number of major septa, and wider dissepimentarium, but the principal difference is in the axial structures, which are simple and prominent in *Ekvasophyllum* and *Turbophyllum* and are more complex and less prominent or absent entirely in *Faberophyllum*.

FABEROPHYLLUM OCCULTUM Parks, n. sp.
Plate 31, figures 1a, b, 4a, b; plate 32, figures 3a, b

Diagnosis.—Large corals with 64 to 70 major septa in ephebic stage; dissepimentarium and minor septa occupy one-third to one-half of radius; small axial complex composed of one or few irregular lamellae, tabellae absent or few and inconspicuous.

Externals.—Moderately curved, trochoid to subcylindrical. Interseptal ridges and septal grooves present. Calyx moderately deep with small boss in center. Cardinal fossula on side of convex curvature.

Transverse sections.—In ephebic stage, dissepimentarium occupies one-third to one-half of radius; dissepiments small, concentric. Septa approach radial symmetry except near prominent cardinal fossula where they are pinnately arranged; 64 to 70 major septa at diameters of 41 to 44 mm. in different individuals, major septa about two-thirds radius long, attenuated continuations of some major septa may reach axis. Minor septa about one-third radius long, longer in cardinal quadrants. Tabular intersections numerous near periphery of tabularium. Cardinal fossula prominent, closed, bounded by fused axial ends of adjoining pinnate major septa. Axial complex small, formed of a small number of irregularly disposed lamellae, with few or no tabellae. Cardinal septum thin and short, counter septum shorter than adjacent major septa, alar septa about equal in length to adjacent major septa.

Longitudinal sections.—Dissepimentarium occupies about one-third of radius; dissepiments elongate, steeply inclined, merge

almost imperceptibly with tabulae. Tabulae incomplete, upturned at outer margins near dissepiments, trend nearly horizontally through most of tabularium. Axial complex formed of few gently inclined tabellae and discontinuous irregular lamellae.

Material.—Specimens studied, 34. Holotype, USNM 116001; paratypes, USNM 116002 and 116003.

Occurrence.—*Faberophyllum occultum*—*F. araneosum* zone, Brazer limestone, Leatham Hollow and Dry Lake, Wasatch Mountains, Utah.

Remarks.—The most distinctive feature of *Faberophyllum occultum* is the axial complex, which is composed of one principal lamella, with or without a few smaller radiating lamellae, all irregular and discontinuous vertically. Tabellae play a very small part in the formation of this axial complex. *F. araneosum* has a larger and more complex axial structure formed of several prominent radiating lamellae and many tabellae. *F. leathamense* has an axial structure composed of several radiating lamellae which are continuous with major septa, and few or no tabellae. *F. pisgahense* has an axial structure composed of several radiating lamellae which are continuous with the axial ends of palmate groups of major septa, and no tabellae. *F. languidum* has no axial structure, and sagging tabulae.

FABEROPHYLLUM ARANEOSUM Parks, n. sp.
Plate 30, figures 1a, b, 2a, b, 4

Diagnosis.—Large corals with 62 to 74 major septa in ephebic stage; dissepimentarium and minor septa occupy about one-third of radius; axial complex composed of several irregular radiating lamellae and numerous tabellae.

Externals.—Moderately curved, trochoid to subcylindrical. Interseptal ridges and septal grooves present, but not conspicuous. Calyx moderately deep, with prominent boss in center. Prominent cardinal fossula on side of convex curvature.

Transverse sections.—In ephebic stage, dissepimentarium occupies about one-third of radius; dissepiments small, concentric. Septa approach radial symmetry except near prominent cardinal fossula where they are pinnately arranged; 62 to 74 major septa at diameters of 32 to 34 mm. in different individuals, major septa about three-fourths radius long, do not reach axis. Minor septa about half as long as major septa. Tabular intersections abundant near periphery of tabularium. Cardinal fossula prominent, closed, bounded by fused axial ends of adjoining pinnate major septa. Axial complex prominent, formed of several irregular radiating lamellae and numerous tabellae. Cardinal septum thin and short, counter septum thin and shorter than adjacent major septa, alar septa about equal in length to adjacent major septa.

Longitudinal sections.—Dissepimentarium occupies about one-third of radius; dissepiments elongate, steeply inclined, distinctly set off from tabularium. Axial complex formed of several irregular, more or less discontinuous lamellae, and numerous small, steeply upturned tabellae.

Material.—Specimens studied, 11. Holotype, USNM 116004; paratype, USNM 116005.

Occurrence.—*Faberophyllum occultum*—*F. araneosum* zone, Brazer limestone, Leatham Hollow, Wasatch Mountains, Utah.

Remarks.—This species is differentiated from the other species of *Faberophyllum*, *F. occultum*, *F. leathamense*, and *F. pisgahense*, by its larger and more complex axial structure in which tabellae play an important role. The differences in tabellae are most clearly seen in longitudinal section.

FABEROPHYLLUM LEATHAMENSE Parks, n. sp.
Plate 32, figures 2a, b, 4

Diagnosis.—Large corals with 80 to 88 major septa in ephebic stage; dissepimentarium and minor septa occupy nearly one-half of radius; axial structure composed of several radiating lamellae continuous with major septa and few or no tabellae.

Externals.—Moderately curved, trochoid to subcylindrical. Interseptal ridges and septal grooves present but not prominent. Calyx not observed. Cardinal fossula on side of convex curvature.

Transverse sections.—In ephebic stage, dissepimentarium occupies one-third to one-half of radius; dissepiments small, concentric. Septa approach radial symmetry except near prominent closed cardinal fossula where they are pinnately arranged; 80 to 88 major septa at diameters of 42 to

48 mm. in different individuals, major septa three-fourths radius length or longer, attenuated ends of a few major septa in each quadrant are continuous with the radiating lamellae of the axial complex. Minor septa one-third to one-half as long as major septa. Tabular intersections numerous near periphery of tabularium, sparse throughout remainder. Cardinal fossula prominent, long, closed, bounded by fused axial ends of adjoining pinnate major septa. Axial complex formed of several radiating lamellae, each continuous with the attenuated axial end of a major septum, tabellae rare or absent entirely. Cardinal septum thin and short, counter and alar septa generally nearly equal in length to adjacent major septa.

Longitudinal sections.—Dissepimentarium occupies nearly one-half of radius; dissepiments elongate, steeply inclined. Tabulae incomplete, upturned at periphery of tabularium to merge imperceptibly with the dissepiments; throughout remainder of tabularium the short arched incomplete tabulae trend nearly horizontally. Axial complex rarely seen in longitudinal section; lamellae are not continuous vertical plates, but low amplexoid-like continuations of a few major septa, and tabellae are absent or very weak.

Material.—Specimens studied, 30. Holotype, USNM 116006; paratype, USNM 116007.

Occurrence.—*Lithostrotion whitneyi—Faberophyllum leathamense* zone, Brazer limestone, Leatham Hollow and Dry Lake, Wasatch Mountains, Utah.

Remarks.—This species differs from *F. occultum* in the nature of the axial complex, which in *F. leathamense* is formed of several radiating lamellae which are continuous with the attenuated axial ends of some of the major septa, but are not visible in longitudinal section; whereas in *F. occultum* the lamellae are seldom if ever continuous with the major septa, and are visible in longitudinal section, though not completely continuous. Tabellae are not prominent in the axial complex of either species.

F. araneosum has a more complex axial structure in which tabellae are prominent. *F. pisgahense* has a similar axial complex to that of *F. leathamense*, but is smaller in diameter, has fewer septa, and the major septa are palmately grouped.

FABEROPHYLLUM PISGAHENSE Parks, n. sp.
Plate 32, figures 1a, b

Diagnosis.—Medium sized corals with 58 to 66 major septa in ephebic stage; dissepimentarium and minor septa occupy about one-third of radius; major septa palmately grouped, with axial ends of each group continuing to axis to form radiating lamellae; no tabellae.

Externals.—Moderately curved, trochoid to subcylindrical in ephebic portion. Interseptal ridges and septal grooves present. Calyx not observed. Cardinal fossula on side of convex curvature.

Transverse sections.—In ephebic stage, dissepimentarium occupies one-third of radius; dissepiments small, concentric. Septa approach radial symmetry, but tend towards palmate grouping, especially in counter quadrants, and are pinnately arranged near prominent cardinal fossula; 58 to 66 major septa at diameters of 25 to 28 mm. in different individuals, most major septa about two-thirds radius long, ends of palmate groups reach axis. Minor septa about half as long as major septa. Tabular intersections numerous near periphery of tabularium, present throughout tabularium. Cardinal fossula very prominent, closed, bounded by fused axial ends of adjoining pinnate major septa. Axial structure formed of several radiating lamellae continuous with the axial ends of palmate groups of major septa; no tabellae. Cardinal septum short, counter and alar septa not easily differentiated from adjacent major septa.

Longitudinal sections.—Dissepimentarium occupies one-third of radius; dissepiments elongate, steeply inclined. Tabulae incomplete, upturned at periphery of tabularium where they merge smoothly with the dissepiments; remainder of tabularium composed of short, arched, incomplete tabulae with a nearly horizontal trend, occasionally slightly turned up at axis. Axial structure not visible in longitudinal section, lamellae discontinuous between tabulae; no tabellae.

Material.—Specimens studied, 9. Holotype, USNM 116008.

Occurrence.—*Faberophyllum occultum–F. araneosum* zone, Brazer limestone, Dry Lake, Wasatch Mountains, Utah.

Remarks.—This species differs from the other species of *Faberophyllum* in its smaller

diameter at subcylindrical ephebic stage, and in the tendency towards palmate grouping of major septa. *F. leathamense* has a similar axial structure with several radiating lamellae and few or no tabellae, but it is much larger than *F. pisgahense*, and there is no tendency towards palmate grouping of septa.

FABEROPHYLLUM LANGUIDUM Parks, n. sp.
Plate 33, figures 1a, b, 2a–c

Diagnosis.—Large corals with 70 to 80 major septa in ephebic stage; dissepimentarium and minor septa occupy one-third to one-half of radius; no axial structure; incomplete tabulae sag conspicuously near the axis.

Transverse sections.—In ephebic stage, dissepimentarium occupies one-third to one-half of radius; dissepiments small, concentric. Septa approach radial symmetry except near prominent cardinal fossula where they are pinnately arranged; 70 to 80 major septa at diameters of 36 to 38 mm. in different individuals, major septa about three-fourths radius long. Minor septa half as long as major septa. Tabular intersections numerous near periphery of tabularium, and abundant around axis. Cardinal fossula very prominent, closed, bounded by fused axial ends of adjoining pinnate major septa. No axial structure. Cardinal septum thin and short, counter and alar septa indistinguishable in length from adjacent major septa.

Longitudinal sections.—Dissepimentarium occupies one-third to one-half of radius; dissepiments elongate, steeply inclined. Tabulae incomplete, upturned at periphery of tabularium to merge smoothly with dissepiments, general trend through mid-portion of tabularium horizontal, distinctly sagging apically near axis. No axial structure.

Material.—Specimens studied, 6. Holotype, USNM 116009; paratype, USNM 116010.

Occurrence.—Upper part of *Faberophyllum occultum–F. araneosum* zone, Brazer limestone, Dry Lake; and *Lithostrotion whitneyi–Faberophyllum leathamense* zone, Brazer limestone, Leatham Hollow, Wasatch Mountains, Utah.

Remarks.—This species differs from the other species of *Faberophyllum* in the total absence of an axial structure, and in the distinct sagging of the tabulae at the axis.

Family LITHOSTROTIONIDAE

Genus LITHOSTROTION Fleming, 1828

Genolectotype: LITHOSTROTION STRIATUM Fleming, 1828

LITHOSTROTION WHITNEYI Meek, 1877
Plate 33, figures 3–5

Lithostrotion whitneyi MEEK, 1877, Paleontology, U. S. Geol. Expl. 40th Par. Rept. (King), vol. 4, p. 58, pl. 6, figs. 1, 1c; WHITE, 1877, U. S. Geog. Surveys W. 100th Mer. Rept. (Wheeler), vol. 4, pt. 1, p. 103, pl. 6, figs. 1a-c; KELLY, 1942, Jour. Paleontology, vol. 16, pp. 359, 360, pl. 51, figs. 2, 5.

The specimens from Dry Lake and Leatham Hollow are quite typical of *L. whitneyi*. This species was described by Meek from specimens collected from Boxelder Peak, Wasatch Mountains, Utah, only a few miles from the Dry Lake locality.

Occurrence.— *Lithostrotion whitneyi–Faberophyllum leathamense* zone, Brazer limestone, Dry Lake and Leatham Hollow, Wasatch Mountains, Utah.

Genus LITHOSTROTIONELLA Yabe & Hayasaka, 1915

Genoholotype: LITHOSTROTIONELLA UNICUM Yabe & Hayasaka, 1915

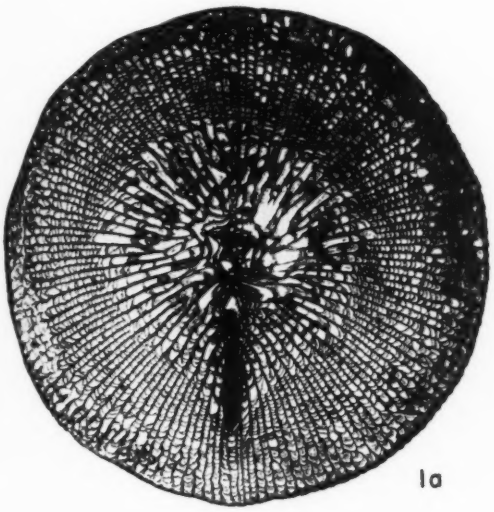
LITHOSTROTIONELLA sp.
Plate 29, figures 2a, b

One poorly preserved specimen of *Litho-*

EXPLANATION OF PLATE 31
All figures ×2

FIGS. *1a, b, 4a, b—Faberophyllum occultum* Parks, n. sp. *1a, b.* Paratype. USNM 116003; *a*, transverse section, ephebic stage; *b* longitudinal section. *4a, b*, Holotype. USNM 116001; *a*, transverse section, ephebic stage; *b*, longitudinal section. (p. 177)

2a, b, 3a, b—Turbophyllum multiconum Parks, n. sp. *2a, b*, Paratype, USNM 116000; *a*, transverse section, ephebic stage; *b*, longitudinal section. *3a, b*, Holotype. USNM 115999; *a*, transverse section, ephebic stage; *b*, longitudinal section. (p. 176)



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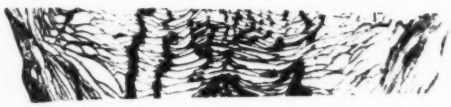

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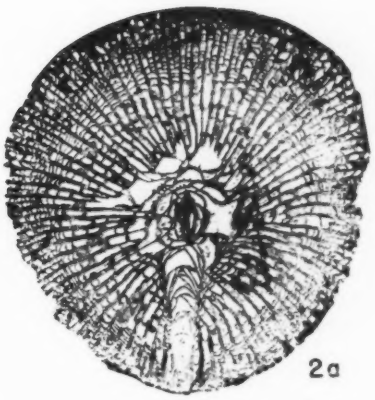
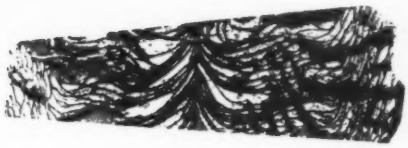


2a



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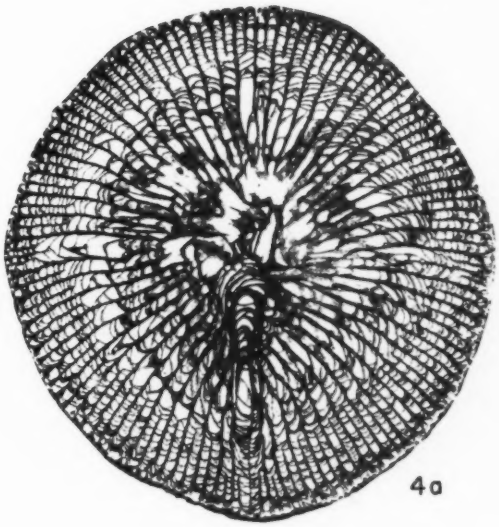
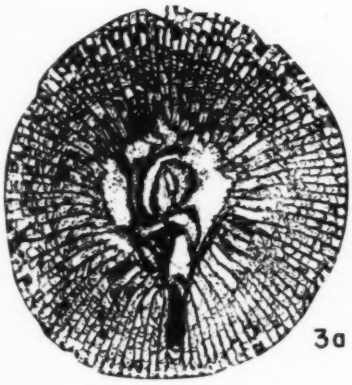
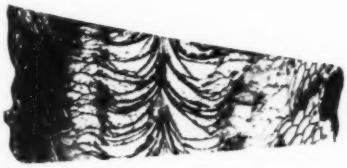


4a



3a

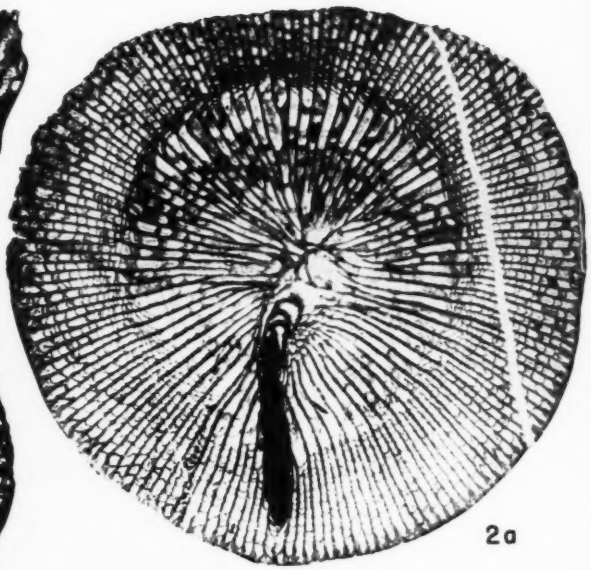


3b

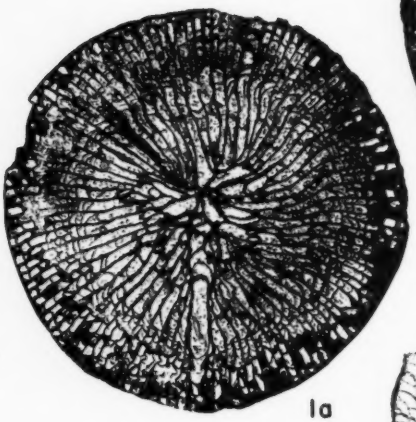
4b

Parks, Upper Mississippian corals from Utah

1b



2a

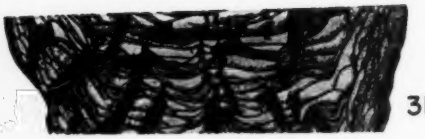


1a

2b

3a

4



3b

Parks, Upper Mississippian corals from Utah

strotionella was collected. It most closely resembles *L. americana* Hayasaka, 1936, although this specimen from the Brazer has fewer septa and a more irregular axial structure.

Occurrence.—Top of *Ekvasophyllum inclinatum* zone, Brazer limestone, Leatham Hollow, Wasatch Mountains, Utah.

Family HAPSIPHYLLIDAE
Genus TRIPLOPHYLLITES Easton, 1944
Genotype: TRIPLOPHYLLITES PALMATUS Easton, 1944
TRIPLOPHYLLITES cf. PALMATUS Easton, 1944
Plate 29, figures 4, 5

Triplophyllites palmatus EASTON, 1944, Illinois Geol. Survey Rept. Inv. 97, p. 35, pl. 8, figs. 1–6.

Externals.—Small, slightly curved, trochoid corals. Septal grooves pronounced. Calyx not observed. Cardinal fossula on side of convex curvature.

Transverse sections.—In ephebic stage, 34 to 36 major septa at diameters of 17 mm. No dissepiments, no minor septa. Major septa dilated, extend to axis. No tabular intersections. Cardinal fossula prominent, extends to axis. Cardinal septum very short.

Longitudinal sections.—Septa are so strongly dilated that longitudinal sections show nothing but septa. No tabulae observed.

Material.—Specimens studied, 5.

Occurrence.—*Triplophyllites* zone, Brazer limestone, Leatham Hollow, Wasatch Mountains, Utah.

Remarks.—These specimens strongly resemble *Triplophyllites palmatus* Easton, but the extremely dilated septa, and lack of evidence of tabulae make specific identification difficult. The range of *T. palmatus* is not known; it was described by Easton from the Kinkaid limestone, upper Chester series, Mississippian, southern Illinois.

TRIPLOPHYLLITES sp. A
Plate 30, figure 5

One well preserved specimen of *Triplophyllites* was found in the *Faberophyllum occultum–F. araneosum* zone at Leatham Hollow. This specimen has 31 major septa at a diameter of 13.5 mm., and shows numerous tabular intersections. No minor septa, no dissepiments. This specimen does not closely resemble *T. palmatus* or any other described species of *Triplophyllites*, but a new species will not be described from this single specimen.

Family CANINIIDAE
Genus CANINIA Michelin in Gervais, 1840
Genotype: CANINIA CORNUCOPIAE Michelin in Gervais, 1840
CANINIA sp. A
Plate 29, figures 6a, b

Several fragments of *Caninia* were collected from the *Caninia* zone of the Dry Lake section, and many more fragments were observed in solid massive limestone faces where collecting was virtually impossible. Of those collected, two of the most complete fragments are illustrated here as *Caninia* sp. A and *Caninia* sp. B.

Caninia sp. A is a very large coral, reconstructed diameter approximately 60 mm., with 68 major septa. Dissepimentarium occupies nearly one-half of radius; dissepiments near periphery large and lonsdaleoid, inner ones smaller and concentric. Major septa about three-fourths radius long, minor septa half as long. In longitudinal section, dissepiments are elongate and inclined; and tabulae are generally complete, horizontal, with strongly downturned margins.

This specimen somewhat resembles *C. bilateralis* Easton, 1945, from the Otter formation, Upper Mississippian, of Montana, but the Brazer specimen is larger, has more septa, and the major septa are shorter. Although this specimen is different from

EXPLANATION OF PLATE 32
All figures ×2

FIGS. *1a, b*—*Faberophyllum pisgahense* Parks, n. sp. Holotype, USNM 116008; *a*, transverse section, ephebic stage; *b*, longitudinal section. (p. 179)
2a, b, 4—*Faberophyllum leathamense* Parks, n. sp. *2a, b*, Holotype, USNM 116006; *a*, transverse section, ephebic stage; *b*, longitudinal section. *4*, Paratype, USNM 116007; transverse section, ephebic stage. (p. 178)
3a, b—*Faberophyllum occultum* Parks, n. sp. Paratype, USNM 116002; *a*, transverse section. ephebic stage; *b*, longitudinal section. (p. 177)

any described species of *Caninia*, a new species will not be named from this single fragmentary specimen.

CANINIA sp. B
Plate 29, figures 7a, b

Caninia sp. B has 44 major septa at a diameter of about 36 mm. Dissepimentarium occupies about one-third of radius; dissepiments small, concentric, angulo-concentric, and herringbone. No minor septa observed. Major septa of cardinal quadrants strongly dilated. In longitudinal section, dissepiments are elongate and steeply inclined; tabulae are complete, horizontal, with downturned margins.

C. sp. B closely resembles *Caninia enormis* Easton, 1945, from the Otter formation, Upper Mississippian, of Montana, but the Brazer specimen is somewhat larger, has more septa, and the tabulae are more regularly and more widely spaced. This specimen is probably within the range of variation of *C. enormis*, but specific identification from one fragmentary specimen is doubtful.

Several other fragments of *Caninia* were collected from the *Caninia* zone of the Dry Lake section, but none were collected or observed in the Leatham Hollow section except in the Pennsylvanian beds which contain the fusulinid *Pseudostaffella* sp.

CORAL ZONATION OF THE BRAZER LIMESTONE

Corals are abundant throughout the greater part of the two sections discussed in this paper. The Leatham Hollow section has been correlated with the Dry Lake section on the basis of the corals common to both sections (fig. 2). Five coral zones have been recognized; however, all five zones are not present in either section.

The coral zones, from bottom to top, are: the *Ekvasophyllum inclinatum* zone; the *Faberophyllum occultum–F. araneosum* zone the *Lithostrotion whitneyi–Faberophyllum leathamense* zone; the *Triplophyllites* zone; and the *Caninia* zone (fig. 2).

The lower 952 feet of the Brazer limestone in the Leatham Hollow section consists of sandstone, siltstone, and arenaceous limestone, and contains no corals and few other fossil invertebrates.

Ekvasophyllum inclinatum zone.—The lowest coral zone in the Leatham Hollow section is the *Ekvasophyllum inclinatum* zone, from 952 to 1223 feet (fig. 2). The fauna of this zone is:

Ekvasophyllum inclinatum Parks
Lithostrotionella sp.
Triplophyllites sp. B
Syringopora spp.

None of these corals, with the exception of the long-ranging *Syringopora*, occur above this zone in Leatham Hollow, or in the Dry Lake section.

Faberophyllum occultum–F. araneosum zone.—The second coral zone in the Leatham Hollow section is the *Faberophyllum occultum–F. araneosum* zone, from 1223 to 1893 feet (fig. 2). The fauna of this zone in the Leatham Hollow section is:

Faberophyllum occultum Parks
F. araneosum Parks
Ekvasophyllum turbineum Parks
Triplophyllites sp. A
Syringopora spp.
Gigantella brazeriana (Girty)

The lower 127 feet of the Dry Lake section (fig. 2) is correlated with the *Faberophyllum occultum–F. araneosum* zone of the Leatham Hollow section on the basis of the occurrence in both sections of *Faberophyllum occultum* Parks, and their similar position immediately beneath the *Lithostrotion whitneyi–Faberophyllum leathamense* zone. The fauna of the *Faberophyllum occultum–F. araneosum* zone in the Dry Lake section is:

Faberophyllum occultum Parks
F. pisgahense Parks
F. languidum Parks
Turbophyllum multiconum Parks
Syringopora spp.
Linoproductus cf. *L. ovatus* (Hall)

Lithostrotion whitneyi–Faberophyllum leathamense zone.—The third coral zone in the Leatham Hollow section is the *Lithostrotion whitneyi–Faberophyllum leathamense* zone, from 1893 to 1980 feet (fig. 2). The fauna of this zone at Leatham Hollow is:

Lithostrotion whineyi Meek
Faberophyllum leathamense Parks
F. languidum Parks
Syringopora spp.

This zone is also present at Dry Lake, from 127 to 288 feet (fig. 2). The fauna of this zone at this locality is:

Lithostrotion whitneyi Meek

Faberophyllum leathamense Parks
Syringopora spp.

Triplophyllites zone.—The fourth coral zone in the Leatham Hollow section is the *Triplophyllites* zone, from 2110 to 2135 feet (fig. 2). The fauna of this zone is:

Triplophyllites cf. *T. palmatus* Easton
Spirifer cf. *S. leidyi* Norwood & Pratten
Linoproductus ovatus (Hall)
Dictyoclostus cf. *D. inflatus* (McChesney)

This fauna does not occur in the Dry Lake section. Above the *Triplophyllites* zone at Leatham Hollow is the lower portion of the Wells formation, Pennsylvanian, containing *Pseudostaffella* sp. and *Caninia* sp.

Stratigraphically above the *Lithostrotion whitneyi–Faberophyllum leathamense* zone at Dry Lake is a zone with few or no corals, from 288 to approximately 1335 feet (fig. 2). The fauna of this zone is:

Chonetes cf. *C. chesterensis* Weller
Gigantella brazeriana (Girty)
Composita cf. *C. sulcata* Weller
Dictyoclostus sp.

Caninia zone.—A fifth coral zone is present in the Dry Lake section which is not present in the Leatham Hollow section. This is the *Caninia* zone, from 1335 to 1970 feet (fig. 2). The fauna of this zone is:

Caninia sp. A
Caninia sp. B
Caninia spp. (fragments)
Syringopora spp.
Spirifer cf. *S. pellaensis* Weller
Composita cf. *C. subquadrata* Hall
Chonetes loganensis Hall & Whitfield

Above the *Caninia* zone, in the pale purple silty limestones near the top of the Dry Lake section, the ammonoid *Eumorphoceras* sp. and other fragmentary ammonoids are found.

The absence from the Leatham Hollow section of the *Caninia* zone and the several hundred feet of cherty limestone associated with it in the Dry Lake section is evidence of a profound erosional unconformity between the Brazer limestone and the Wells formation. The occurrence of these extra zones in the Dry Lake section probably accounts for the thicker section of limestone exposed there.

EVOLUTION OF BRAZER CORALS

The abundant occurrence of morphologically similar tetracorals throughout the essentially unbroken sequence of lithologically similar limestones of the Brazer formation offers an opportunity to study the evolution of these corals.

The best method of approach to phylogeny is a morphologic comparison of adult stages and of the whole ontogeny, with strict attention to detailed chronology (Hill, 1938, pp. 35, 36). Carruther's study of the evolution of the *Zaphrentis delanouei* gens (1910, pp. 523–538) is the classic application of this method.

Ontogenetic evidence in the Brazer corals is insufficient as a result of the general lack of preservation of the apical ends of these corals. Therefore, this discussion is limited almost entirely to a morphologic comparison of adult growth stages, and to the stratigraphic order of occurrence. The little ontogenetic evidence now available appears to support the postulated line of development.

The characteristics of this group of corals that are common to all of the evolutionary stages, and that remain essentially unchanged are:

(1) The prominent cardinal fossula closed at the axial end by downwarped tabulae.

(2) The pinnate arrangement of the major septa of the cardinal quadrants.

(3) The fusion of the axial ends of some of the pinnate septa with the fossular walls.

(4) The wide zone of small concentric dissepiments.

(5) The predominantly incomplete tabulae with upturned peripheral edges at the juncture with the dissepiments.

The characteristics of this group of corals that change during the postulated evolution are:

(1) The general increase in the size of the mature corallite, with exceptions.

(2) The general increase in the number of septa in the mature corallite, with exceptions.

(3) The change in the nature of the axial structure, from a solid rod-like columella, to an acrocolumella formed of nesting tent-shaped tabulae, to an irregular axial complex formed of radiating lamellae and tabellae, to less and less vertically continuous lamellae and the disappearance of tabellae,

and finally to the total absence of any form of axial structure.

(4) The change in the general trend of the tabulae, from an upward inclination toward the axis, to an essentially horizontal trend, and finally to a distinct sagging of the tabulae at the axis.

Figure 3 illustrates the stratigraphic sequence of the evolutionary stages of the Brazer corals with line drawings of transverse and longitudinal sections of the tabularium only, excluding the dissepimentarium, in order to emphasize the characteristics that change most with time. The stratigraphic locations of these stages are indicated on the Correlation and Coral Zonation Chart, figure 2, by their corresponding Roman numerals.

Stage I.—Ekvasophyllum inclinatum Parks has 42 to 46 major septa at 18 to 20 mm. diameters, a solid rod-like columella, and incomplete tabulae that arch upward axially to join the columella.

Stage II.—Ekvasophyllum turbineum Parks has 50 to 56 major septa at 24 to 26 mm. diameters, a solid rod-like columella that is more laterally compressed than that in *E. inclinatum*, and incomplete tabulae that turn sharply upward axially to merge smoothly with the columella.

Stage III.—Turbophyllum multiconum Parks has 56 to 72 major septa at 27 to 28 mm. diameters, and an acrocolumella composed of nesting tent-shaped tabulae.

Stage IV.—Faberophyllum araneosum Parks has 62 to 74 major septa at 32 to 34 mm. diameters, an axial complex formed of irregular radiating lamellae and numerous tabellae, and tabulae with a general horizontal trend, disregarding the axial tabellae.

Stage V.—Faberophyllum occultum Parks has 64 to 70 major septa at 41 to 44 mm. diameters, an axial structure formed of one or few lamellae and few or no tabellae, and tabulae with a general horizontal trend.

Stage VI.—Faberophyllum leathamense Parks has 80 to 88 major septa at 42 to 48 mm. diameters, an axial structure formed of several radiating lamellae continuous with the attenuated axial ends of major septa, but discontinuous vertically, and few or no tabellae, and tabulae with a general horizontal trend.

Stage VII.—Faberophyllum pisgahense Parks is a departure from the general evolutionary line, with 58 to 66 major septa at 25 to 28 mm. diameters, an axial structure formed by several radiating lamellae continuous with the axial ends of palmate groups of major septa, lamellae discontinuous vertically, no tabellae, and short incomplete arched tabulae with a general horizontal trend.

Stage VIII.—Faberophyllum languidum Parks has 70 to 80 major septa at 36 to 38 mm. diameters, no axial structure, and incomplete tabulae with a distinct axial sag towards the apical end of the corallite.

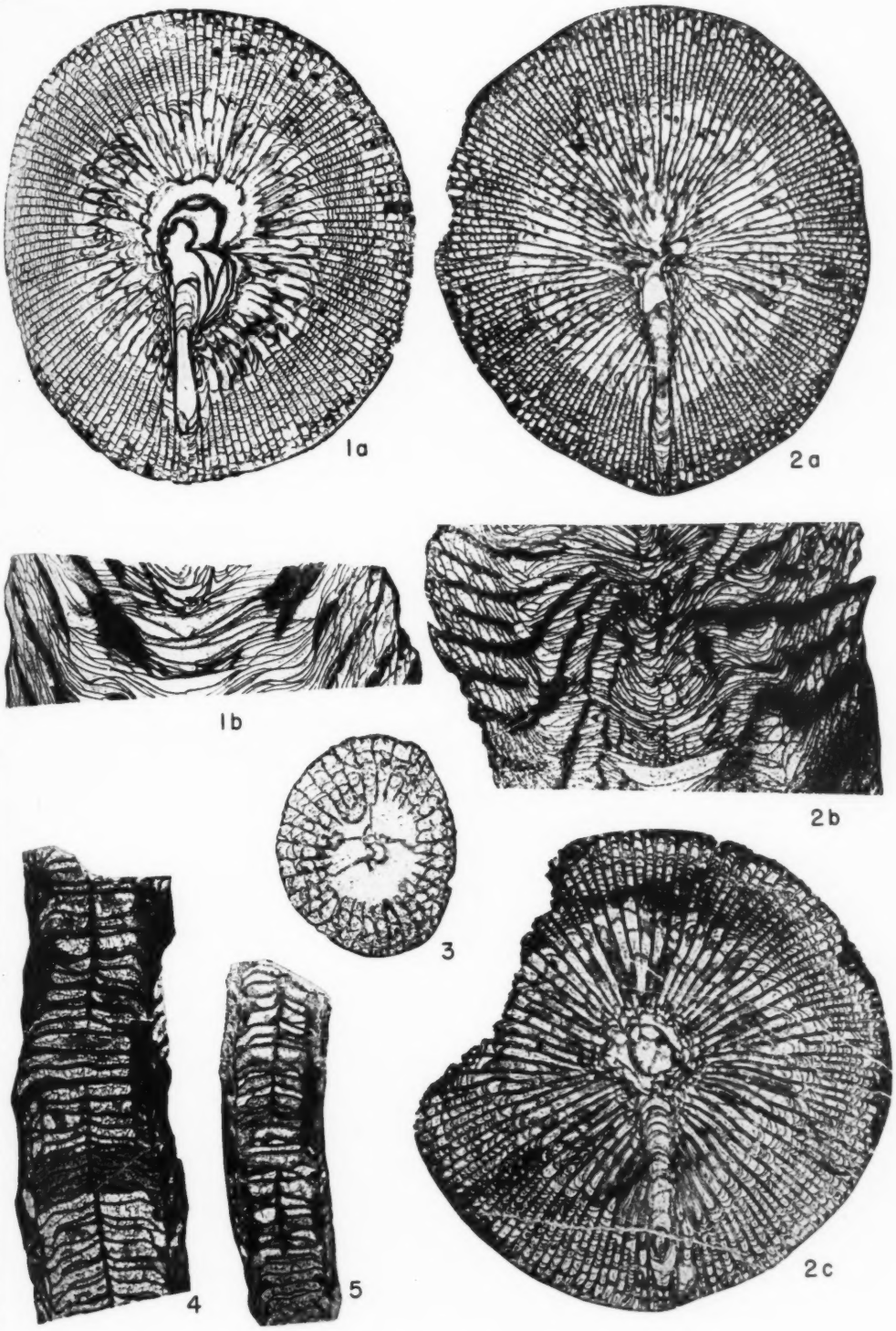
Ontogenetic evidence is lacking for most of the evolutionary stages, but the ontogeny of one specimen of Stage III, *Turbophyllum multiconum* Parks, indicates the presence of a solid columella in the neanic growth stages.

The evolution of these corals does not appear to follow closely any of the major trends outlined by Lang (1923, pp. 120-136). There appears to be a slight tendency for the expression of the caninoid trend in the form of corallite, from trochoid to cylindroid, in the early stages of the evolution of these corals, but it is not carried further in the later stages. The change in the nature of the axial structures of the Brazer corals may be an expression of the aulophylloid trend in the form of the central column toward complexity and irregularity of the central column, although Lang does not mention the complete disappearance of the axial structure as part of this trend.

EXPLANATION OF PLATE 33
All figures ×2

FIGS. *1a, b, 2a–c—Faberophyllum languidum* Parks, n. sp. *1a, b*, Holotype. USNM 116009; *a*, transverse section, ephebic stage; *b*, longitudinal section. *2a–c*, Paratype, USNM 116010; *a*, transverse section, late ephebic stage; *b*, longitudinal section; *c*, transverse section, middle ephebic stage. (p. 180)

3–5—Lithostrotion whitneyi Meek. *3*, Transverse section; *4, 5* longitudinal sections. (p. 180)



Parks, Upper Mississippian corals from Utah

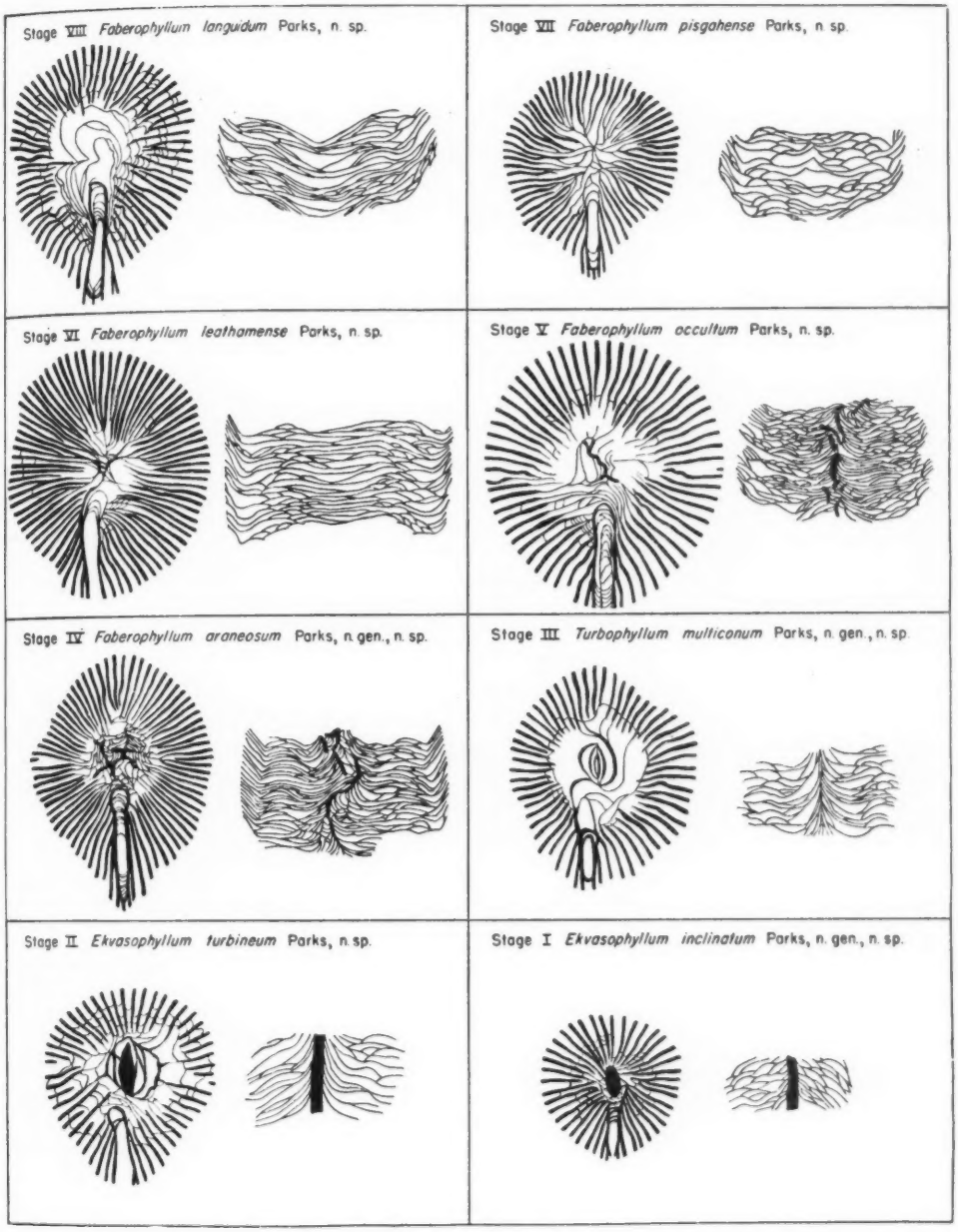

Stage VIII Faberophyllum languidum Parks, n. sp.
Stage VII Faberophyllum pisgahense Parks, n. sp.
Stage VI Faberophyllum leathamense Parks, n. sp.
Stage V Faberophyllum occultum Parks, n. sp.
Stage IV Faberophyllum araneosum Parks, n. gen., n. sp.
Stage III Turbophyllum multiconum Parks, n. gen., n. sp.
Stage II Ekvasophyllum turbineum Parks, n. sp.
Stage I Ekvasophyllum inclinatum Parks, n. gen., n. sp.

FIG. 3—Stratigraphic sequence of evolutionary stages of Brazer corals. Drawings show transverse and longitudinal sections of tabularium only, excluding dissepimentarium, in order to emphasize the characteristics that change most with time. Stratigraphic locations of these stages are indicated on figure 2 by their corresponding Roman numerals. All figures approximately ×1.5.

CONCLUSIONS

(1) Because of the lack of adequate specific descriptions of *Zaphrentis? multilamellata* Hall, *Z. stansburii* Hall, and *Z. excentrica* Meek, and because the types of these species will probably not be sectioned in the near future, new specific names are applied to the corals collected from the Brazer limestone in the area considered in this paper. Furthermore, since these corals do not belong to the genus *Zaphrentis* (sensu stricto), nor to the various genera proposed for Carboniferous "zaphrentid" corals, three new genera are proposed, containing eight new species.

(2) Five coral zones are recognized in the Brazer limestone, each characterized by certain of the new species described in this paper, or by other genera and species illustrated in this paper. Neither stratigraphic section of the Brazer contains all five coral zones. The absence of the *Caninia* zone from the Leatham Hollow section indicates a profound erosional unconformity between the Brazer limestone, Mississippian, and the Wells formation, Pennsylvanian.

(3) An evolutionary sequence is proposed for the morphologically similar Brazer corals described in this paper, based principally on morphologic comparison of adult growth stages and on stratigraphic order of occurrence.

REFERENCES

CARRUTHERS, R. G., 1910, On the evolution of *Zaphrentis delanouei* in Lower Carboniferous times: Geol. Soc. London Quart. Jour., vol. 66, pp. 523–538.

DINGWALL, J. M. M., 1926, On *Cyathoclisia*, a new genus of Carboniferous coral: Geol. Soc. London Quart. Jour., vol. 82, pp. 12–21.

EASTON, W. H., 1944, Corals from the Chouteau and related formations of the Mississippi Valley region: Illinois Geol. Survey Rept. Inv. 97.

——, 1945, Corals from the Otter formation (Mississippian) of Montana: Jour. Paleontology, vol. 19, pp. 522–528.

GIRTY, G. H. in MANSFIELD, G. R., 1927, Geography, geology, and mineral resources of part of southeastern Idaho: U. S. Geol. Survey Prof. Paper 152, pp. 411–477.

HALL, JAMES in STANSBURY, HOWARD, 1855, An expedition to the valley of the Great Salt Lake of Utah. Philadelphia, Lippincott, Grambo and Co.

HAYASAKA, I., 1936, On some North American species of *Lithostrotionella:* Taihoku Imp. Univ. Mem. Fac. Sci. and Agriculture, vol. 13, no. 5 (Geology no. 12).

HILL, D., 1935, British terminology for rugose corals: Geol. Mag., vol. 72, no. 11, pp. 481–519.

——, 1938–1941, A monograph on the Carboniferous rugose corals of Scotland, Pts. 1–4: Palaeont. Soc. London, vols. 91, 92, 94, 95.

——, 1948, The distribution and sequence of Carboniferous coral faunas: Geol. Mag., vol. 85, no. 2, pp. 121–148.

KELLY, W. A., 1942, Lithostrotiontidae in the Rocky Mountains: Jour. Paleontology, vol. 16, pp. 351–361.

LANG, W. D., 1923, Trends in British Carboniferous corals: Geologists' Assoc. London Proc. vol. 34, pp. 120–136.

MEEK, F. B., 1877, Paleontology: U. S. Geol. Expl. 40th Parallel Rept. (King), vol. 4, pt. 1.

RICHARDSON, G. B., 1913, The Paleozoic section in northern Utah: Am. Jour. Sci., ser. 4, vol. 36, pp. 406–416.

——, 1941, Geology and mineral resources of the Randolph Quadrangle, Utah-Wyoming: U. S. Geol. Survey Bull. 923.

SANFORD, W. G., 1939, A review of the families of tetracorals, Pts. 1, 2: Am. Jour. Sci., vol. 237, pp. 295–323; no. 6, pp. 401–423.

SCHINDEWOLF, O. H., 1938, Zur Kenntnis der Gattung *Zaphrentis* (Anthoz., Tetracorall.) und der sogenannten Zaphrentiden des Karbons: Preuss. Geol. Landesanstalt Jahrb., (1937), vol. 58, pp. 439–454.

SLOSS, L. L., 1945, Corals from the post-Osage Mississippian of Montana: Jour. Paleontology, vol. 19, pp. 309–314.

WARREN, P. S., 1927, Banff area, Alberta: Canada Geol. Survey Mem. 153.

WILLIAMS, J. STEWART, 1943, Carboniferous formations of the Uinta and northern Wasatch Mountains, Utah: Geol. Soc. America Bull., vol. 54, pp. 591–624.

——, 1948, Geology of the Paleozoic rocks, Logan Quadrangle, Utah: Geol. Soc. America Bull., vol. 59, pp. 1121–1164.

——, and YOLTON, J. S., 1945, Brazer (Mississippian) and lower Wells (Pennsylvanian) section at Dry Lake, Logan Quadrangle, Utah: Am. Assoc. Petroleum Geologists Bull., vol. 29, pp. 1143–1155.

JOURNAL OF PALEONTOLOGY, VOL. 25, NO. 2, PP. 187–199, PLS. 34–35, 1 TEXT FIGURE, MARCH 1951

THE GENUS *GLOBOTRUNCANA* IN TRINIDAD, B. W. I.

NOTES ON OCCURRENCE, NOMENCLATURE AND RELATIONSHIPS BETWEEN SPECIES

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ABSTRACT—This paper deals with some taxonomic problems of the genus *Globotruncana* Cushman. Particular attention is paid to the double keeled species which are subdivided into two main groups of different morphological characteristics and stratigraphic range. Eighteen *Globotruncana* species and subspecies from Trinidad, of which four are new, are listed or described and their stratigraphic distribution is summarized in a range chart. In addition, an attempt is made to give a picture of their probable relationships.

INTRODUCTION

Since Cushman and Renz published their note in 1947, the knowledge of Upper Cretaceous Foraminifera of Trinidad, particularly of the genus *Globotruncana* Cushman, has increased considerably. More detailed study of the Upper Cretaceous type localities and the addition of more complete sections by deep drilling has led to the recording of a number of *Globotruncana* species and subspecies which previously were unknown from this island. Some of these are new, others are known from various European localities and from the Gulf Coast region of America.

Globotruncana-bearing Upper Cretaceous beds outcrop only as incomplete sections at a few localities in central and southern Trinidad, but drilling in the usually richly foraminiferal upper Senonian and Maestrichtian, from which most of the new information comes, has given a good picture of the stratigraphic distribution of the species and subspecies of this genus.

The exploration of Trinidad's Upper Cretaceous is still in progress, and it can be expected that new and more accurate information concerning the foraminiferal fauna will be forthcoming.

Disposition of types.—The holotypes of the listed new species are deposited in the Cushman Collection at the United States National Museum. Paratypes of these species are being sent to the Museum of Natural History, Basel, Switzerland.

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NOMENCLATURE

The taxonomy of the genus *Globotruncana* Cushman is still in an unsatisfactory state and clarification would be most desirable in view of the stratigraphic importance of the genus. Morphologically identical specimens have been figured under synonymous names, and also there are cases where specimens of distinct specific characteristics have been recorded under a single name.

This situation has, in the writer's opinion, resulted mainly from inadequate figures or descriptions and the fact that in many cases thin sections only can be used. The reliable comparison of a thin section with an entire specimen is exceedingly difficult and incorrect determinations are easily made. Since the number of peripheral keels, course of ventral and dorsal suture lines, degree of convexity, etc., are decisive for specific determination, dorsal, ventral and peripheral views are indispensable for accurate illustration.

An attempt at a complete solution of the nomenclatural problems would require a

monographic revision of the genus and is beyond the scope of the present article. The following suggestions and observations, some of which have already been mentioned on an earlier occasion (Bolli, 1944), are only submitted as a contribution toward this end.

In view of the very rapid tempo of evolution, a minute specific subdivision of *Globotruncana* is desirable. Characteristics important for stratigraphic subdivision, such as the number of peripheral keels, the course of suture lines, etc., are regarded as sufficient basis for specific identification. In addition, certain minor deviations from central types are often recognizable, as, for example, change in degree of convexity of dorsal and ventral sides. It has been observed that these minor variations may be of stratigraphic significance. For this reason the writer is of the opinion that the term subspecies should be used in preference to variety. Trinominal nomenclature for such minor categories of *Globotruncana* was first applied by Vogler (1941) and later by Bolli (1944) to a group of double keeled forms. Subsequently Cita (1948) extended the same system to the single keeled Cenomanian groups of *Globotruncana apenninica* Renz and *G. ticinensis* Gandolfi.

The genera *Rotalipora* Brotzen (1942) and *Thalmanninella* Sigal (1948) have been erected in recent years. They possess, in common with the early species of *Globotruncana*, a single peripheral keel and are recorded from the Cenomanian and Turonian, but differ from this genus, according to the definitions, by their peculiar apertures and coverplates over the umbilicus. It might be of interest to mention in this connection that the genus *Globotruncana* has also been described as possessing an umbilical coverplate (Cushman, 1940, p. 295: "Aperture ventral, in well preserved specimens with a thin plate-like structure over the umbilical area").

Rotalipora turonica, described by Brotzen, varies further from the *Globotruncana apenninica* group by the possession of radial, instead of curved, ventral suture lines and more inflated chambers. Other single keeled early forms described under *Globotruncana* (*G. ticinensis* Gandolfi, *G. benacensis* Cita, *G. stephani* Gandolfi) show, on the other hand, radial ventral suture lines and a comparatively small umbilicus. As far as can be ascertained by the writer, however, no details of the arrangement of their apertures have been published, probably due to the usually poor state of preservation of these parts. It is therefore possible that some of these *Globotruncana* species belong to *Rotalipora*, particularly *G. benacensis*, some specimens of which the author has had opportunity to study.

Sigal (1948) is probably correct in placing *Globorotalia cushmani* Morrow (Cushman, 1946, pl. 62, figs. 9a-c) of the Greenhorn formation (Turonian) in this genus.

It also appears possible that *Globotruncana alpina* Bolli, known only in thin sections, from the upper Cenomanian of the Swiss Alps, belongs to *Rotalipora*, since the side view of *R. turonica* (Brotzen, 1942, fig. 10) shows certain affinities to this species (Bolli, 1944, fig. 1, nos. 5–7).

Rotalipora globotruncanoides Sigal (1948, pl. 1, figs. 4a–c, pl. 2, figs. 4a, b) differs, however, from the other species of this genus by its distinctly curved ventral suture lines and a wider umbilicus. When the external features only are considered, this form shows strong similarity to the *G. apenninica* group. The same applies to *Thalmanninella brotzeni* Sigal (1948, pl. 1, figs. 5a–c, pl. 2, figs. 6a, b, 7). In regard to the former, however, it may be questioned whether it is a true *Rotalipora* in the sense of Brotzen's definition.

Sigal states that badly preserved specimens of *R. globotruncanoides* have probably been determined as *Globotruncana* by some authors, particularly as *G. apenninica*. It is of interest to note in this connection that neither O. Renz (1936), who placed *G. apenninca* only provisionally in the genus *Globotruncana*, nor any later author known to the writer, has mentioned details of the apertures of that species. The possibility therefore exists that either *Rotalipora globotruncanoides* or *Thalmanninella brotzeni* may be synonymous with the insufficiently described *G. apenninica*.

It is agreed in general (e.g., O. Renz, 1936; Gandolfi, 1942) that the single keeled *G. apenninica* Renz evolved through *G. renzi* Thalmann & Gandolfi into the double keeled group of *G. lapparenti* Brotzen (table 1), which also shows the typically

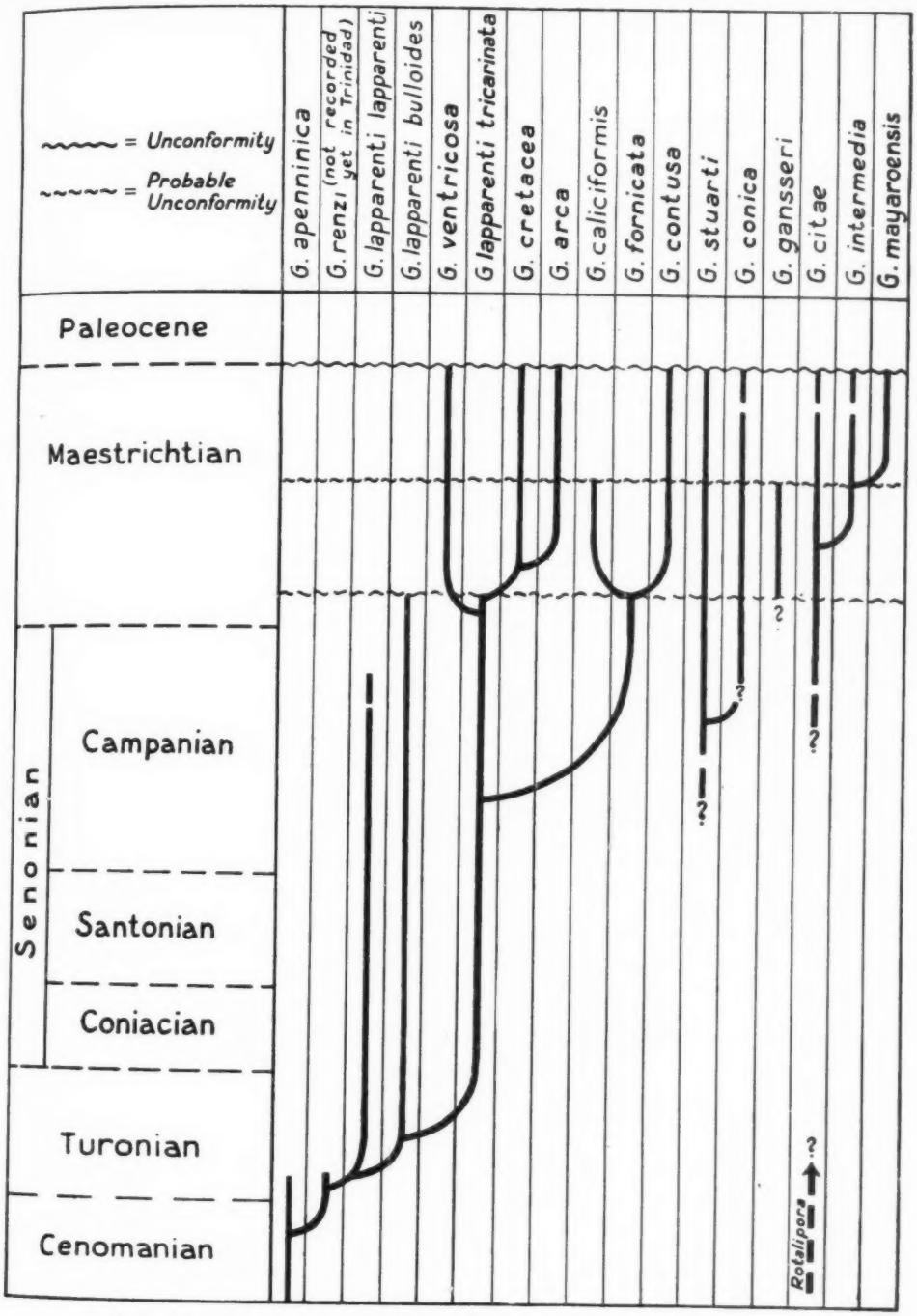


TABLE 1.—TENTATIVE EVOLUTION CHART OF TRINIDAD *Globotruncanae*

curved ventral suture lines. Very little is known so far, however, of the apertures of these younger species. Until more information is obtained from detailed studies on well preserved material the evolution of this group from *R. globotruncanoides* or *T. brotzeni* is therefore still a possibility.

Considering external features only, one arrives at the conclusion that species of

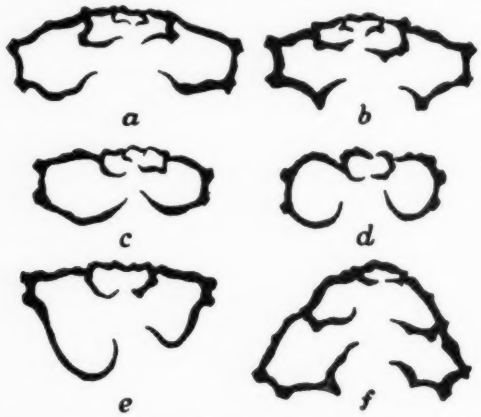


FIG. 1—Axial sections of some characteristic double keeled *Globotruncanae*. *a*, *G. lapparenti lapparenti*; *b*, *G. lapparenti tricarinata*; *c*, *G. lapparenti bulloides*; *d*, *G. globigerinoides*; *e*, *G. ventricosa*; *f*, *G. contusa*.

Rotalipora with radial ventral sutures are probably not the ancestors of the *G. lapparenti* group. Links in the evolution of the single keeled to double keeled forms of *Rotalipora* possibly can be found in the new species *Globotruncana citae*, *G. intermedia* and *G. mayaroensis*, which also possess radial ventral suture lines, but, due to poor preservation, their apertures have not yet been observed in detail.

Parallel evolution of two genera from single keeled to double keeled forms would be apparent if such a connection can be established. The change would take place for the *Globotruncana apenninica* (*?Rotalipora globotruncanoides*, *?Thalmanninella brotzeni*), *Globotruncana renzi* (transition form), *Globotruncana lapparenti* group at the Cenomanian-Turonian boundary and for the *Rotalipora turonica*, *Rotalipora cushmani*, *Globotruncana* [*?Rotalipora*] *citae*, *Globotruncana* [*?Rotalipora*] *intermedia*, *Globotruncana* [*?Rotalipora*] *mayaroensis* group in the Maestrichtian. The two groups would differ in the course of the ventral suture lines (curved in the first, radial in the second) and probably in the position and number of apertures. The presence of a coverplate over the umbilicus would be less significant, as it can be found in both genera.

Most of the Trinidad specimens are not sufficiently well preserved to allow a detailed study of the apertures. For this reason all the forms described from Trinidad for the time being have been placed in the genus *Globotruncana* despite the possibility that some of them may belong to *Rotalipora* or *Thalmanninella*. This applies in particular to *G. citae*, *G. intermedia* and *G. mayaroensis*, which show distinct radial ventral suture lines, as does *Rotalipora*.

The possibility that *Rotalipora* may have developed from single keeled into double keeled forms must be kept in mind when reading the following section on double keeled forms of *Globotruncana* (table 1). Those with radial ventral suture lines described there (*G. mayaroensis*) may actually belong to the genus *Rotalipora*.

DOUBLE KEELED *Globotruncanae*

A short explanation will suffice to introduce the name *Globotruncana lapparenti* Brotzen and its subspecies, since this problem has already been discussed in detail (Bolli, 1948, pp. 227–230).

Brotzen (1936) observed that many of the doubled keeled forms described under the name of *Globotruncana linneiana* (d'Orbigny) are not identical with the original type figured in 1839. He came to the conclusion that this species, *Globotruncana canaliculata* (Reuss) and *Globotruncana ventricosa* White differ in width of umbilicus and degree of convexity of the chambers, but all seem to be characterized by a more or less radial direction of the suture lines on the ventral side. On the other hand, all the specimens described by de Lapparent in 1918 from Hendaye (Pyrenees) as *Rosalina linnei* (d'Orbigny), should be grouped separately because of differences mainly confined to the ventral side. The most important of these is that the suture lines are not radial, each chamber overlapping the next younger one in such a manner that the sutures are curved with the convex side directed forward.

This peculiarity characterizes the double keeled specimens from Hendaye, and, in fact, is also present in most Upper Cretaceous assemblages of the Alpine-Mediterranean region. Brotzen suggested for this new group the name *Globotruncana lapparenti*. This group, as previously mentioned, differs, according to Brotzen, from forms described by him from the north European Upper Cretaceous and from d'Orbigny's original figure of *Rosalina linneiana* from Cuba.

De Lapparent himself had already subdivided the *Rosalina linnei* group of Hendaye into "types 1–6." These types can be morphologically distinguished and thus should be given subspecific rank, especially as some of them occur in different stratigraphic zones. Based on these considerations, the writer elevated de Lapparent's "types 1–4" to subspecies of *Globotruncana lapparenti* (Bolli, 1944). "Types 5 and 6" have been excluded as probably separate species. The following names were proposed:

Globotruncana lapparenti lapparenti Bolli as central type of the species (=type 1 of de Lapparent).

G. lapparenti tricarinata (Quereau) (=type 2)

G. lapparenti bulloides (Vogler) (=type 3)

G. lapparenti coronata Bolli (=type 4)

It appears that most of the double keeled forms described under the name *Globotruncana linnei* and also many of the *G. canaliculata* and *G. marginata* types fall in the *G. lapparenti* group. In addition to these from the Alpine-Mediterranean area, those described by Vogler (1941) from the Netherlands East Indies and by Cushman (1946) from North America doubtless belong here.

Recent observations of specimens from the Upper Cretaceous of Trinidad seem to throw additional light on the problem of these presumably different groups of double keeled forms. The writer found that after typical *G. lapparenti* died out, probably in late Campanian or early Maestrichtian time, a new double keeled *Globotruncana* appeared suddenly, but probably not immediately, after the disappearance of the earlier type. This later form, described below as *G. mayaroensis*, appears to be related to the group with radial ventral suture lines.

Based on this observation, we can distinguish in Trinidad the following two types of double keeled forms:

1. *Globotruncana lapparenti* Brotzen with suture lines more or less curved on ventral side. Turonian to Maestrichtian.

2. *Globotruncana mayaroensis* Bolli with radial suture lines on ventral side. Maestrichtian.

This would confirm Brotzen's assumption of the existence of a *Globotruncana lapparenti* group distinct from another group with radial suture lines, in which he included *G. linneiana*, *G. canaliculata* and *G. ventricosa*. Since these two groups were not found together, it had been supposed previously (Brotzen, 1936; Bolli, 1944) that they lived in different regions. Both have now been found in Trinidad, however, showing that their apparent separation may be due to differences of stratigraphic range rather than of geographic distribution. The Maestrichtian of the Alpine-Mediterranean region is often incomplete and frequently poorly fossiliferous, and this possibly accounts for the non-recognition of the younger types in that area up to the present time.

The writer has come to the conclusion that Brotzen was mistaken in excluding *G. canaliculata* from the *G. lapparenti* group, probably being misled by inadequate figures. He may, however, have attributed forms of the *G. mayaroensis* type to this older species. More recent figures of *G. canaliculata* specimens derived from the same area as the original types (Cushman, 1946, pl. 61, figs. 18a–c) fulfill the criteria for the *G. lapparenti* group. It would be of interest to check d'Orbigny's figure of *Rosalina linneiana*, which shows radial sutures on the ventral side, with the actual type from Cuba. Possibly one might come to a similar conclusion as regarding *G. canaliculata* and *G. lapparenti*. The position of *G. ventricosa* in this connection is discussed below.

The further question arises as to whether Reuss's *Rosalina canaliculata* 1854 and/or *Rosalina marginata* 1845 could be synonymous with *R. linneiana* 1839. Until these problems are clarified, the writer suggests for the purpose of convenience and simplification that all the double keeled specimens which fulfill the general requirements of *Globotruncana lapparenti* Brotzen be regarded as subspecies of it.

For the above reasons *G. canaliculata*

(Reuss) and *G. marginata* (Reuss), described by Cushman (1946, pl. 61, fig. 17, pl. 62, fig. 2) from the Gulf Coast area, are treated in the following list of Trinidad forms as being synonymous to *G. lapparenti lapparenti* and *G. lapparenti bulloides*, respectively.

It may be thought that *Globotruncana arca* (Cushman) (1946, pl. 62, figs. 4a–c) is related to *G. mayaroensis*. The life range of the former, which was described by Cushman as being very limited in the Taylor and Navarro of the Gulf Coast area, would more or less agree with findings in Trinidad. The more or less radial suture lines on the ventral side (Cushman, 1946, pl. 62, fig. 4b) give further support to this assumption. However, *G. mayaroensis* differs morphologically from some specimens of *G. arca* received by the writer from Dr. Cushman that show only a faint development of the lower keel which tends to disappear entirely on the last chambers. Furthermore, there are more chambers in the last whorl than in *G. mayaroensis*. The writer is inclined, therefore, to group this species with the later double keeled forms which are also present in Trinidad.

The double keeled *Globotruncana fornicata* Plummer, *G. contusa* (Cushman), *G. caliciformis* (de Lapparent), *G. ventricosa* White, *G. cretacea* Cushman and *G. arca* (Cushman) show such distinct characteristics that they have to be treated as separate species. Their morphologic features indicate that they are genetically related to the *G. lapparenti* group. The lower marginal keel of this group is not as strongly developed as the dorsal one and has the tendency to disappear completely, especially on the final chambers. Some species of this group are typified by strong ventral (*G. ventricosa*) or dorsal (*G. contusa*) inflation. Curved ventral suture lines, characteristic of the *G. lapparenti* group, are often observed. It is probable that the species *G. leupoldi* Bolli, known only from thin sections, must also be included in this group.

Globotruncana fornicata occurs in Trinidad with the late forms of *G. lapparenti*. Others (*G. caliciformis*, *G. cretacea*, *G. arca*) are present only in younger strata.

Cita (1948) considers that some of these species are transitional forms leading from typical *G. lapparenti* to the single keeled *G. stuarti-G. conica-G. rosetta* group in the same way that *G. renzi* represents a transitional form between the single keeled *G. apenninica* and *G. lapparenti* groups. Occurrences in Trinidad do not fully favor such an assumption because single keeled specimens of the *G. stuarti* (flat to slightly convex on the dorsal side, practically unlobated) and *G. conica* type appear to be present before the incoming of most of these transitional forms. It is possible, however, that the *G. caliciformis* or *G. cretacea-G. arca* group might lead in its late evolution stage to such forms as the more lobate *G. rosetta* in which the second keel has disappeared completely, at least on the chambers of the last whorl. If this could be proved there would be two groups of single keeled Campanian-Maestrichtian forms derived from different stocks and with partly different ranges.

An attempt is made in table 1 to illustrate the relationships of the *Globotruncana* species and subspecies recorded in Trinidad. The upper Senonian and Maestrichtian part is based on observations made in Trinidad, while the Cenomanian-lower Senonian part, of which no continuous section is known in Trinidad, shows the evolution as it appears to be recorded in European sections.

EXPLANATION OF PLATE 34
All figures ×65

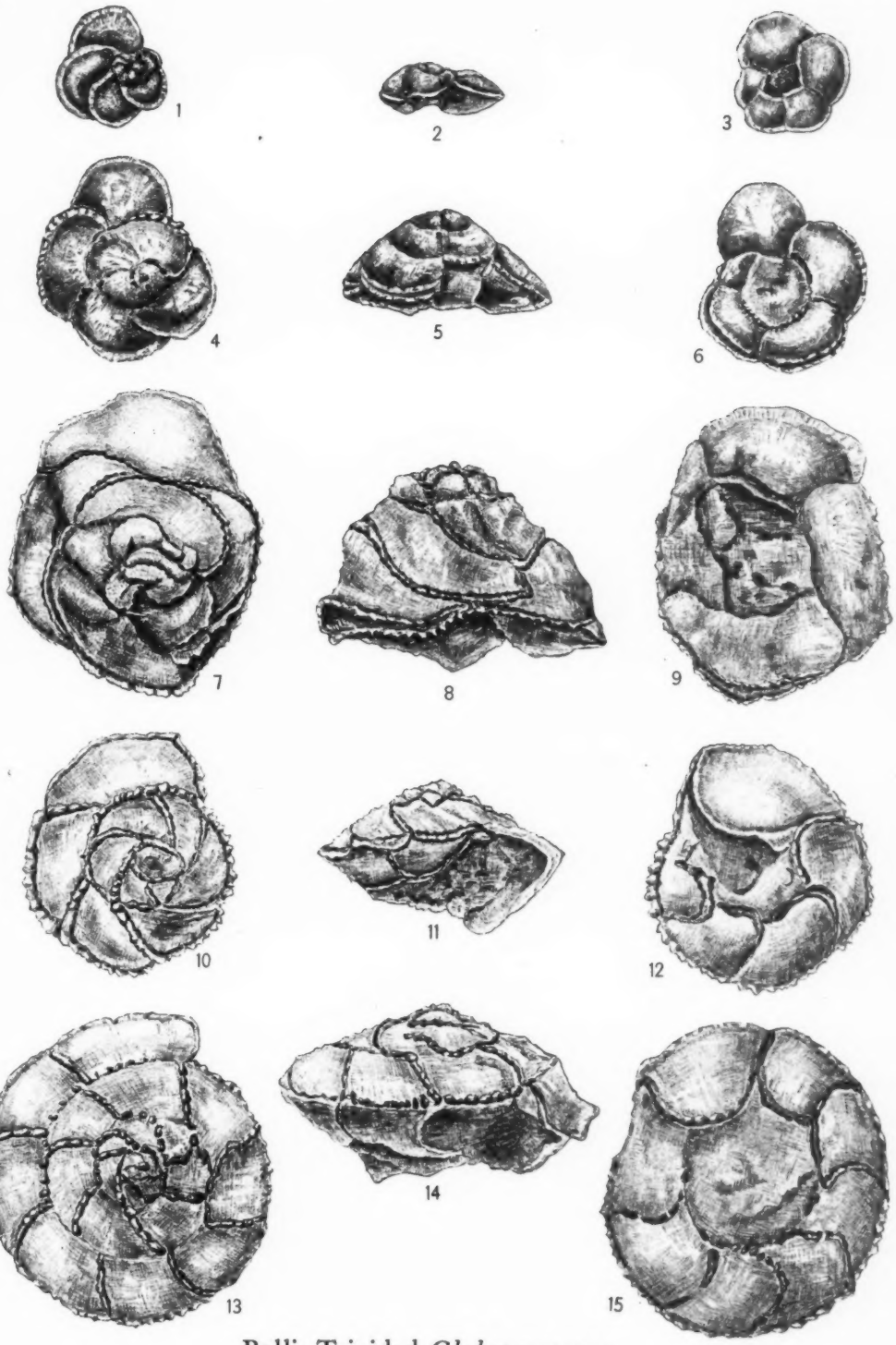
FIGS. *1–3*—*Globotruncana apenninica* cf. a Gandolfi. *1*, Dorsal view; *2*, side view; *3*, ventral view. (p. 193)

4–6—*Globotruncana caliciformis* (de Lapparent). *4*, Dorsal view; *5*, side view; *6*, ventral view. (p. 194)

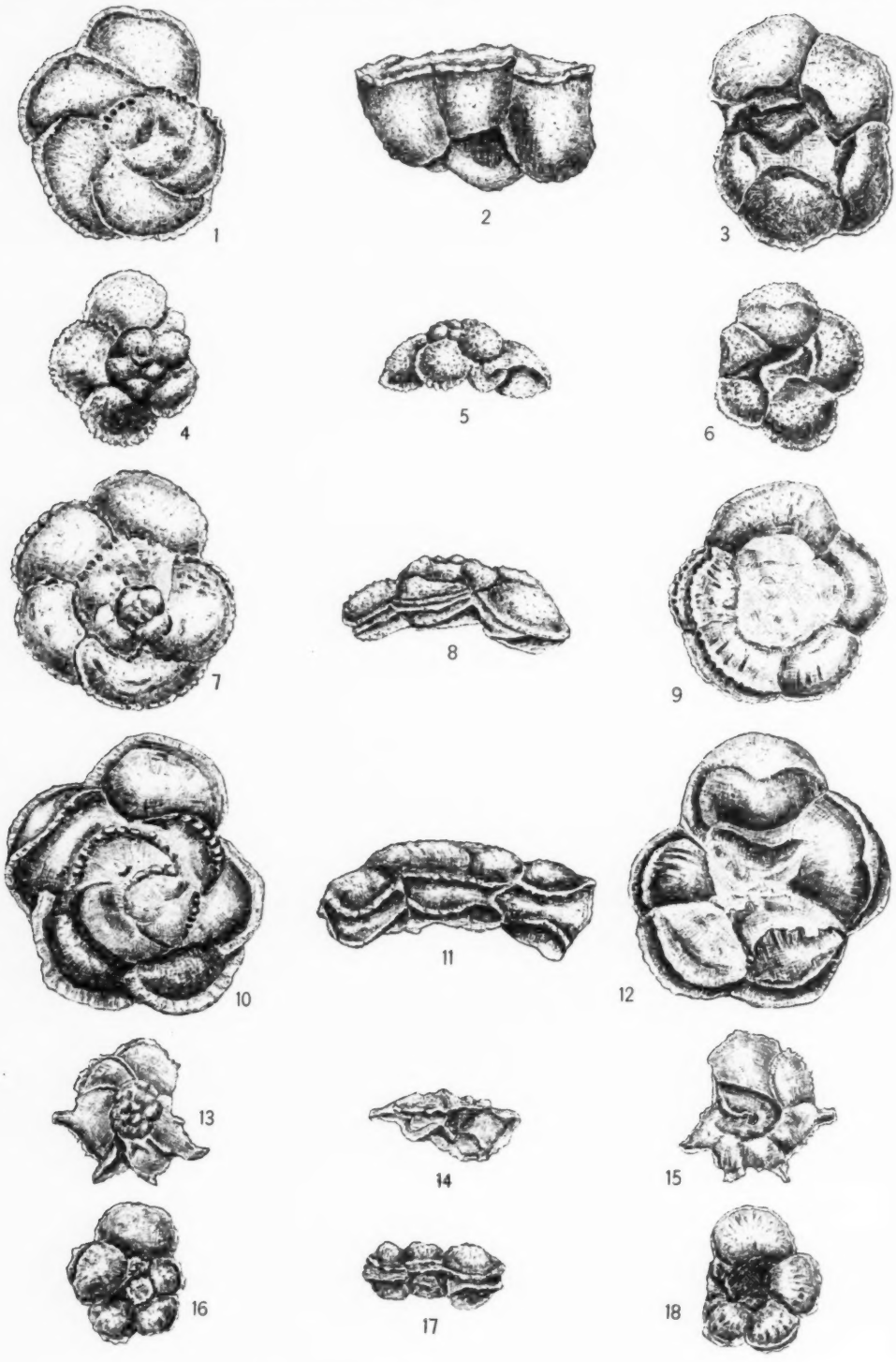
7–9—*Globotruncana contusa* (Cushman). *7*, Dorsal view; *8*, side view; *9*, ventral view. (p. 196)

10–12—*Globotruncana stuarti* (de Lapparent). *10*, Dorsal view; *11*, side view; *12*, ventral view. (p. 196)

13–15—*Globotruncana conica* White. *13*, Dorsal view; *14*, side view; *15*, ventral view. (p. 196)



Bolli, Trinidad *Globotruncanae*



Bolli, Trinidad *Globotruncanae*

LIST OF THE SPECIES AND SUBSPECIES OF *Globotruncana* RECORDED IN TRINIDAD

In the following list full descriptions are given only for new species and for those which have not yet been described in detail from America. A short list of synonyms is presented where necessary, and occasional references are made to Cita's (1948) valuable observations on material from the Lake Garda area of northern Italy.

The more important Trinidad Upper Cretaceous localities which have yielded the material for the present paper are listed below:

1. *Lantern marl.*—(Cushman and Renz, 1947). Probably Maestrichtian. Outcrop in river bed south of bridge near 12½ milepost of Guaracara-Tabaquite Road, Lantern Estate, Central Range. This is a tectonic wedge in younger beds.

2. *Subsurface section.*—Light to medium gray calcareous shale and massive, hard creamy-gray silicious shale with varying calcareous content ("Argiline" of Naparima Hill formation). Senonian to Maestrichtian. Guayaguayare area, County of Mayaro, southeast Trinidad.

3. *Subsurface section.*—Brighton area, near Pitch Lake, southwest Trinidad.

4. *Pointe-à-Pierre Railway Cut marl.*—(Cushman and Renz, 1947). Senonian to Maestrichtian. About 300 feet north of Pointe-à-Pierre railway station in east bank of cutting, western Central Range. Various lenses of different ages included in younger beds.

5. *Naparima Hill formation.*—Massive, hard, creamy-gray silicious shale with varying calcareous content ("Argiline"), in places with thin layers of less indurated shale (former "Tarouba formation, lower member" of Cushman and Renz, 1947). Senonian to ?Maestrichtian. Naparima Hill, San Fernando.

6. *Shale components.*—From Plaisance boulder bed. Turonian or lower Senonian. Hermitage Estate area, western Central Range.

7. *Gautier shale.*—Dark gray to black, fine-bedded calcareous shale. Cenomanian or lower Turonian. Gautier River, Chert Hill area, eastern Central Range.

Genus GLOBOTRUNCANA Cushman, 1927

GLOBOTRUNCANA APENNINICA cf. α Gandolfi

Plate 34, figures 1–3

Globotruncana apenninica var. α GANDOLFI, 1942, Riv. italiana paleontologia, anno 48, pp. 116–123, figs. 40a–c, pl. 4, fig. 12.

The single keeled *G. apenninica*, described by O. Renz from the Cenomanian-lower Turonian of the central Apennines, has been subdivided into varieties α, β and γ by Gandolfi (1942). These were subsequently elevated to subspecies by Cita (1948).

Thalmann (1942) reported the probable presence of *G. apenninica* in the Franciscan limestone, Santa Clara County, California.

Occurrence in Trinidad.—Gautier shale.

GLOBOTRUNCANA LAPPARENTI LAPPARENTI Bolli

Rosalina linnei type 1 DE LAPPARENT, 1918, Carte géol. France Mém., p. 4, figs. a, c.

Globotruncana linnei (D'ORBIGNY); RENZ, 1936, Eclogae geol. Helvetiae, vol. 29, no. 1, pl. 6, figs. 32–34; GANDOLFI, 1942, Riv. italiana paleontologia, anno 48, pp. 125–130, pl. 3, fig. 3, pl. 4, figs. 18, 32, 33, pl. 4, fig. 7.

Globotruncana linnei typica VOGLER, 1941, Palae-

EXPLANATION OF PLATE 35

All figures ×65

FIGS. *1–3—Globotruncana gansseri* Bolli, n. sp. Holotype: *1*, dorsal view; *2*, side view; *3*, ventral view. (p. 196)

4–6—Globotruncana citae Bolli, n. sp. Holotype: *4*, dorsal view; *5*, side view; *6*, ventral view. (p. 197)

7–9—Globotruncana intermedia Bolli, n. sp. Holotype: *7*, dorsal view; *8*, side view; *9*, ventral view. (p. 197)

10–12—Globotruncana mayaroensis Bolli, n. sp. Holotype: *10*, dorsal view; *11*, side view; *12*, ventral view. (p. 198)

13–15—Globotruncana cf. *calcarata* Cushman. *13*, dorsal view; *14*, side view; *15*, ventral view. (p. 198)

16–18—Globotruncana cf. *globigerinoides* Brotzen. *16*, dorsal view; *17*, side view; *18*, ventral view. (p. 198)

ontographica, supplement, vol. 4, p. 286, pl. 23, figs. 12–21.
Globotruncana lapparenti lapparenti BOLLI, 1944, Eclogae geol. Helvetiae, vol. 37, no. 2, p. 230, fig. 1, no. 15, no. 16, pl. 9, fig. 11; CITA, 1948, Riv. italiana paleontologia, anno 54, fasc. 4, pp. 155–156, pl. 4, figs. 2a–c.
Globotruncana canaliculata (REUSS); CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 149, pl. 61, figs. 17a–c.

Occurrence in Trinidad.—Guayaguayare area, component of Plaisance boulder bed.

GLOBOTRUNCANA LAPPARENTI BULLOIDES Vogler

Rosalina linnei type 3 DE LAPPARENT, 1918, Carte géol. France Mém., p. 4, fig. 1h, p. 5, figs. 2a, e. g.
Globotruncana linnei bulloides VOGLER, 1941, Palaeontographica, supplement, vol. 4, pl. 23, figs. 32–39.
Globotruncana lapparenti bulloides BOLLI, 1944, Eclogae geol. Helvetiae, vol. 37, no. 2, pp. 231–232, fig. 1, no. 17, no. 18, pl. 9, fig. 12.
Globotruncana marginata (REUSS). CUSHMAN 1946, U. S. Geol. Survey Prof. Paper 206, p. 150, pl. 62, figs. 1a–c, 2a–c.

Occurrence in Trinidad.—Lantern marl, Guayaguayare area, Brighton area, Pointe-à-Pierre Railway Cut marl, "Argiline" of Naparima Hill.

GLOBOTRUNCANA LAPPARENTI TRICARINATA (Quereau)

Pulvinulina tricarinata QUEREAU, 1893, Beitr. geol. Karte der Schweiz, 33 Lief, pl. 5, fig. 3a.
Rosalina linnei type 2 DE LAPPARENT, 1918, Carte géol. France Mém., p. 4, figs. 1b, d, e, f, S. 5, figs. 2d, n.
Globotruncana linnei (D'ORBIGNY); RENZ, 1936, Eclogae geol. Helvetiae, vol. 29, no. 1, p. 19, pl. 6, figs. 28–30, pl. 8, fig. 7; GANDOLFI, 1942, Riv. italiana paleontologia, anno 48, pl. 10, fig. 7.
Globotruncana linnei tricarinata VOGLER, 1941, Palaeontographica, supplement, vol. 4, pl. 23, figs. 22–31.
Globotruncana lapparenti tricarinata BOLLI, 1944, Eclogae geol. Helvetiae, vol. 37, no. 2, pp. 232–233, fig. 1, no. 19, no. 20, pl. 9, fig. 13; CITA, 1948, Riv. italiana paleontologia, anno 54, fasc. 4, pp. 157–158, pl. 4, figs. 4a–c.
Globotruncana canaliculata (REUSS); CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 149, pl. 61, figs. 18a–c.

Occurrence in Trinidad.—Lantern marl, Guayaguayare area, Brighton area, Pointe-à-Pierre Railway Cut marl, "Argiline" of Naparima Hill.

GLOBOTRUNCANA VENTRICOSA White

Globotruncana ventricosa WHITE; CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 150, pl. 62, figs. 3a–c; CITA, 1948, Riv. italiana paleontologia, anno 54, fasc. 4, pp. 162–163, pl. 4, figs. 9a–c.

Occurrence in Trinidad.—Guayaguayare area, Pointe-à-Pierre Railway Cut marl.

GLOBOTRUNCANA CRETACEA Cushman

Globotruncana cretacea CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 151, pl. 62, figs. 7a–c; CITA, 1948, Riv. italiana paleontologia, anno 54, fasc. 4, pp. 152–153, pl. 3, figs. 7a–c.

Occurrence in Trinidad.—Lantern marl, Guayaguayare area, Brighton area, ?Pointe-à-Pierre Railway Cut marl.

GLOBOTRUNCANA ARCA (Cushman)

Globotruncana arca (CUSHMAN), 1946, U. S. Geol. Survey Prof. Paper 206, p. 150, pl. 62, figs. 4a–c.

This species needs a more accurate definition. Many existing figures are misleading or inadequate. It has already been noted by Cita (1948) that Cushman (1948, pl. 62, figs. 4 and 5) figured two specimens of *G. arca* which do not belong to the same species. His figure 5 with a single keel (according to Cita, *G. rosetta*) probably belongs to the *G. stuarti* group, while his figure 4 corresponds with *G. arca* as defined by its author in earlier publications.

Occurrence in Trinidad.—Lantern marl, Guayaguayare area, ?Pointe-à-Pierre Railway Cut marl.

GLOBOTRUNCANA FORNICATA Plummer

Globotruncana fornicata PLUMMER. CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 149, pl. 61, figs. 19a–c; CITA, 1948, Riv. italiana paleontologia, anno 54, fasc. 4, pp. 153–154, pl. 3, figs. 8a–c.

Occurrence in Trinidad.—Guayaguayare area, Brighton area, Pointe-à-Pierre Railway Cut marl, "Argiline" of Naparima Hill.

GLOBOTRUNCANA CALICIFORMIS (de Lapparent) Plate 34, figures 4–6

Rosalina linnei mutation *caliciforme* DE LAPPARENT, 1918, Carte géol. France Mém., p. 8, fig. 2j, pl. 1, fig. 2.
Globotruncana linnei calciformis VOGLER, 1941, Palaeontographica, supplement, vol. 4, p. 288, pl. 24, fig. 23.
Globotruncana caliciformis (DE LAPPARENT). CITA, 1948, Riv. italiana paleontologia, anno 54, fasc. 4, pp. 148–149, pl. 3, figs. 4a–c.

The types found in Trinidad compare

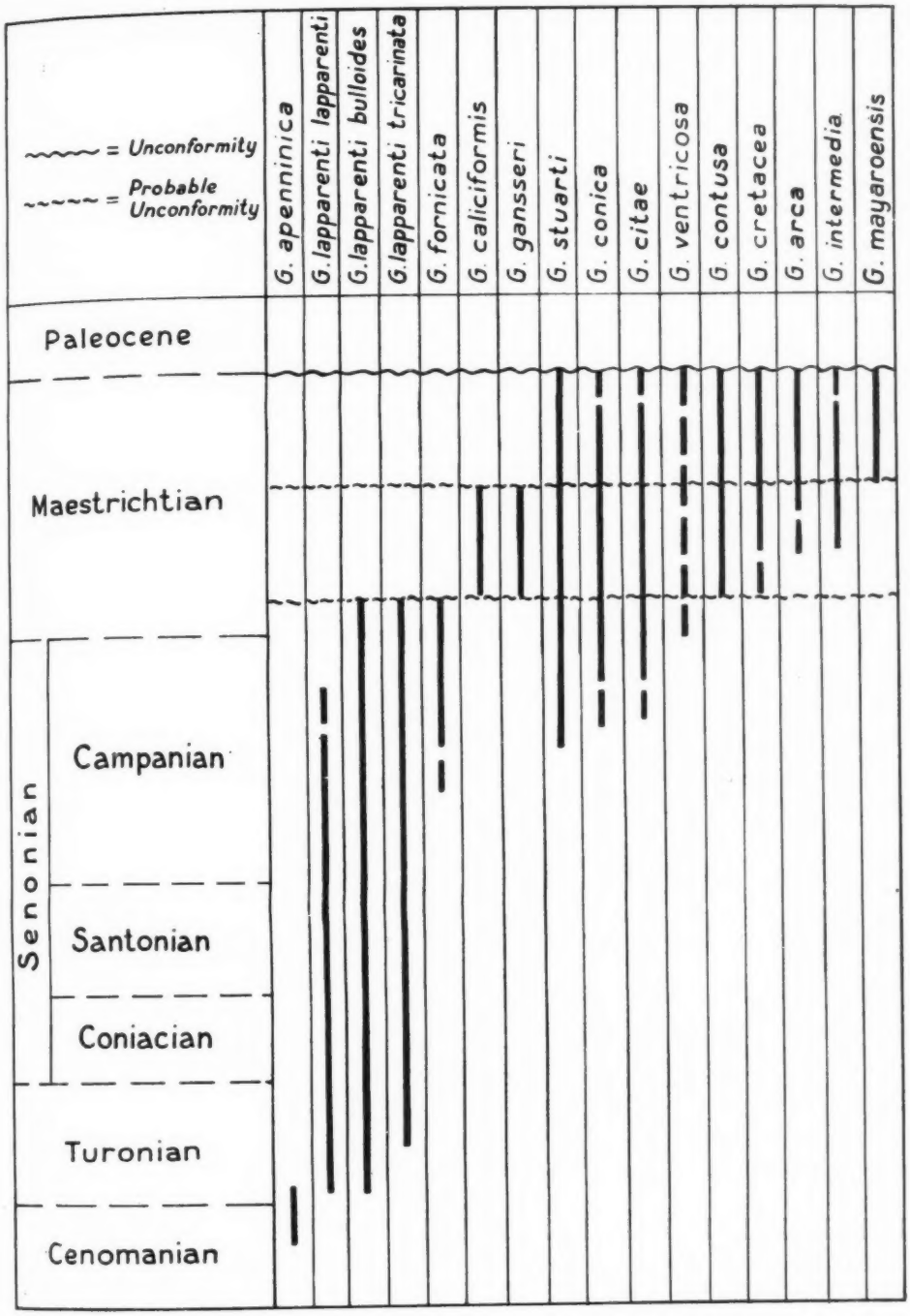


TABLE 2.—DISTRIBUTION OF *Globotruncana* SPECIES AND SUBSPECIES IN TRINIDAD, B. W. I.

well with the figure given by Cita (1948). It was noted by that author that *G. caliciformis* seems to be closely related to *G. fornicata*, of which it is probably a late form. In contrast to that species, which shows depressions on each late chamber, *G. caliciformis* is rather uniform and normally more convex on the dorsal side. The ventral side is flat or slightly convex. The suture lines are smooth or very finely beaded and curved on the dorsal side, less so on the ventral. The periphery is lobate; the chambers very truncate, with two marginal keels, the lower one usually weaker and, in many cases, disappearing on the adult chambers. There are four to six chambers in the last whorl.

Occurrence in Trinidad.—Lantern marl, Guayaguayare area, Brighton area.

GLOBOTRUNCANA CONTUSA (Cushman)
Plate 34, figures 7–9

Globotruncana arca var. *contusa* (CUSHMAN), 1946, U. S. Geol. Survey Prof. Paper 206, pp. 150–151, pl. 62, figs. 6a–b.
Globotruncana conica var. *plicata* WHITE. CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 151, pl. 61, figs. 21a–c; —— & RENZ, 1947, Cushman Lab. Foram. Research Contr., vol. 23, pt. 2, p. 50, pl. 12, fig. 13.
Globotruncana contusa (CUSHMAN). CITA, 1948, Riv. italiana paleontologia, anno 54, fasc. 4, pp. 150–151, pl. 3, figs. 6a–c.

Cita (1948) treats *G. arca* var. *contusa* (Cushman) as a separate species. She came to this conclusion after a consideration of its relationship to *G. arca*, *G. conica* var. *plicata*, *G. conica* and *G. caliciformis*. Observations made in Trinidad favor such a change, but it appears from the occurrence of probable transitional forms that this species is more closely related to *G. fornicata*.

Occurrence in Trinidad.—Lantern marl, Guayaguayare area, Brighton area, Pointe-à-Pierre Railway Cut marl.

GLOBOTRUNCANA STUARTI (de Lapparent)
Plate 34, figures 10–12

Rosalina stuarti DE LAPPARENT, 1918, Carte géol. France Mém., p. 12, fig. 4, S. 13, fig. 5.
Globotruncana stuarti (DE LAPPARENT). RENZ, 1936, Eclogae geol. Helvetiae, vol. 29, no. 1, p. 19, pl. 6, figs. 35–41, pl. 8, fig. 6; VOGLER, 1941, Palaeontographica, supplement, vol. 4, pl. 23, figs. 40, 41; BOLLI, 1944, Eclogae geol. Helvetiae, vol. 37, no. 2, p. 236, fig. 1, no. 27, no. 28, pl. 9, fig. 18; CITA, 1948, Riv. italiana paleontologia, anno 54, fasc. 4, pp. 160–161, pl. 4, figs. 7a–c.
Globotruncana arca (CUSHMAN), 1946, U. S. Geol. Survey Prof. Paper 206, pl. 62, figs. 5a-c; —— & RENZ, 1947, Cushman Lab. Foram. Research Contr., vol. 23, pt. 2, p. 50, pl. 12, ?fig. 11.

The single keeled *G. stuarti* has not yet been described from America under this name, but it appears evident that the species has been figured on several occasions under the name of *G. arca*. Studies of the considerable variation in degree of convexity of the ventral and dorsal sides, shape of chambers, stratigraphic range, etc., might lead to a further subdivision of this species. The single keeled *G. conica* is probably related to *G. stuarti*.

G. arca, figured by Cushman and Jarvis (1932), is a *Globorotalia aragonensis* Nuttall and not *G. rosetta* or *G. stuarti*, as reported by some authors (e.g., Cita, 1948).

Occurrence in Trinidad.—Lantern marl, Guayaguayare area, Brighton area, Pointe-à-Pierre Railway Cut marl, "Argiline" of Naparima Hill.

GLOBOTRUNCANA CONICA White
Plate 34, figures 13–15

Globotruncana conica WHITE. CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 151, pl. 61, figs. 20a–c; —— & RENZ, 1947, Cushman Lab. Foram. Research Contr., vol. 23, pt. 2, p. 50, pl. 12, fig. 12; CITA, 1948, Riv. italiana paleontologia, anno 54, fasc. 4, pp. 149–150, pl. 3, figs. 5a–c.

Cita (1948) considers *G. conica* to be closely related to *G. arca* and possibly to *G. caliciformis*. Since it occurs in Trinidad in strata older than those bearing these species, a relation to *G. stuarti* appears more probable.

Occurrence in Trinidad.—Lantern marl, Guayaguayare area, Pointe-à-Pierre Railway Cut marl, "Argiline" of Naparima Hill.

GLOBOTRUNCANA GANSSERI Bolli, n. sp.
Plate 35, figures 1–3

Test flat on dorsal side, ventrally strongly inflated. The chambers of the last whorl, usually five in number, surround a deep umbilicus. The suture lines on the dorsal side are curved and in many cases finely beaded. A distinct marginal keel separates

the flat dorsal part from the inflated ventral side.

The suture lines of the ventral side are slightly curved, indicating a slight overlapping of chambers. The wall, and particularly the ventral part of it, is somewhat rough or spiny.

The morphological habitus of *G. gansseri* seems in many ways closely related to *G. helvetica* from the Upper Cretaceous of Switzerland (Bolli, 1944, pp. 226–227, fig. 1, no. 9 to no. 12, pl. 9, figs. 6–8). *G. gansseri* appears to be less lobate, however, has fewer chambers, and the initial portion does not rise above the final chambers on the dorsal side as often occurs in *G. helvetica*. The latter species also has a very short life range, but occurs at the Cenomanian-Turonian boundary and is thus definitely older than *G. gansseri*. It probably originated from a *Globigerina*-like form, and the same has to be assumed for *Globotruncana gansseri* since no transitions between this characteristic species and others have been observed.

Dimensions.—Diameter, 0.33 mm.–0.6 mm.; thickness, 0.17 mm.–0.4 mm. Holotype: diameter, 0.53 mm.; thickness, 0.27 mm.

Range.—Part of Maestrichtian.

Occurrence in Trinidad.—Lantern marl, Guayaguayare area, Brighton area (holotype, Cushman Collection No. 59687), Pointe-à-Pierre Railway Cut marl.

Name.—This species is named after Dr. A. Gansser, former Chief Geologist of United British Oilfields of Trinidad, Ltd.

GLOBOTRUNCANA CITAE
Bolli, n. sp.
Plate 35, figures 4–6

The test is usually small, convex on the dorsal, flat or slightly concave on the ventral side, and has a distinctly lobate periphery. The four to five chambers which form the last whorl are truncate in typical specimens and often show only a partially developed marginal keel. The suture lines are dorsally radial or slightly curved, and radial on the ventral side. The walls are usually covered with very fine spines. The state of preservation of the specimens so far examined has not allowed detailed study of the aperture or apertures, which probably open into the umbilicus.

Rosalina foveolata, described by Ehrenberg in 1840 from the Cretaceous of Cattolica (Sicily), appears to be closely related to this species, but the single dorsal view and very short type description do not allow a closer comparison.

Dimensions.—Diameter, 0.33 mm.–0.47 mm.; thickness, 0.14 mm.–0.27 mm. Holotype; diameter, 0.4 mm.; thickness, 0.16 mm.

Range.—Part of Maestrichtian.

Occurrence in Trinidad.—Lantern marl (holotype, Cushman Collection No. 59683), Guayaguayare area, Pointe-à-Pierre Railway Cut marl, "Argiline" of Naparima Hill.

Name.—This species is named after Dr. M. B. Cita for her contribution to the study of the genus *Globotruncana*.

GLOBOTRUNCANA INTERMEDIA
Bolli, n. sp.
Plate 35, figures 7–9

The test is usually slightly convex on the dorsal side, flat or often slightly convex ventrally, and distinctly lobate, but this is less pronounced than in *G. citae*. The five, occasionally four, chambers of the last whorl usually possess a marked peripheral edge or keel, and sometimes a second keel is developed (transition to *G. mayaroensis*). The sutures on the dorsal side are distinctly curved, whereas ventrally they are radial. The chambers often appear slightly inflated and a few show striations, which are radial on the ventral side and more tangential dorsally. The state of preservation of the specimens so far examined has not allowed detailed study of the aperture or apertures, which probably open into the umbilicus.

This species is intermediate between *G. citae* and *G. mayaroensis*. Specimens which cannot definitely be placed as one of these three species have been encountered. It can be assumed, therefore, that *G. intermedia* evolved from *G. citae* and led to *G. mayaroensis*, and has thus a transitional position equivalent to that of *G. renzi* between *G. apenninica* and *G. lapparenti*.

Dimensions.—Diameter, 0.3 mm.–0.6 mm.; thickness, 0.15 mm.–0.3 mm. Holotype: diameter, 0.5 mm.; thickness, 0.2 mm.

Range.—Part of Maestrichtian.

Occurrence in Trinidad.—Lantern marl (holotype, Cushman Collection No. 59681),

Guayaguare area, Brighton area, Pointe-à-Pierre Railway Cut marl.

GLOBOTRUNCANA MAYAROENSIS
Bolli, n. sp.
Plate 35, figures 10–12

The test has a lobate periphery and is flat or slightly convex on the dorsal side. The last chambers in many cases become slightly inflated dorsally, giving to the upper side of the test a somewhat uneven appearance. The sidewall, which is limited by the marginal dorsal and ventral keels, also, in some specimens, appears slightly convex in the last chambers. The ventral side of the test is concave, but the last chambers are, as on the dorsal side, in many specimens more or less inflated. Chambers of the last whorl do not always follow one another uniformly, some being arranged more or less obliquely with respect to one another.

The suture lines on the dorsal side are strongly curved, the initial parts clearly beaded and later very strongly developed. They are radial on the ventral side. The last whorl is usually formed by five chambers, but four are also common. Six chambers have been noted only in one specimen. The preservation of the specimens so far examined has not allowed detailed study of the aperture or apertures, which probably open into the umbilicus. A coverplate over the umbilicus with several apertures seems to be present, however, in some of the better preserved specimens.

As already stated, the specific and stratigraphic characteristics of this species allow it to be distinguished from the *G. lapparenti* group. Information on *G. mayaroensis* is still incomplete, but as far as can be determined, it seems to have evolved from *G. citae* via *G. intermedia* and thus it probably had no connection with the *G. lapparenti* group.

Dimensions.—Diameter, 0.4 mm.–0.8 mm.; thickness, 0.16 mm.–0.3 mm. Holotype: diameter, 0.6 mm.; thickness, 0.27 mm.

Range.—Part of Maestrichtian.

Occurrence in Trinidad.—Guayaguayare area (holotype, Cushman Collection No. 59685), Brighton area, Pointe-à-Pierre Railway Cut marl.

Name.—This species is named after the County of Mayaro, Trinidad, where it was first noted

GLOBOTRUNCANA cf. CALCARATA
Cushman
Plate 35, figures 13–15

Globotruncana calcarata CUSHMAN, 1946, U. S. Geol. Survey Prof. Paper 206, p. 151, pl. 62, figs. 8a–c.

Small specimens with peripheral spines like those of *G. calcarata* Cushman occur reworked in the upper Eocene of the San Fernando area.

GLOBOTRUNCANA cf. GLOBIGERINOIDES
Brotzen
Plate 35, figures 16–18

Globotruncana globigerinoides BROTZEN, 1936, Sveriges geol. undersökning, ser. C, no. 396, Arsbok 30, no. 3, pl. 12, figs. 3a–c, pl. 13, fig. 3; BOLLI, 1944, Eclogae geol. Helvetiae, vol. 37, no. 2, pp. 233–234, fig. 1. no. 23, no. 24, pl. 9, fig. 16.

Small specimens with *Globigerina*-like inflated chambers and a faint peripheral double keel occur reworked in the upper Eocene of the San Fernando area.

REFERENCES

BOLLI, H., 1944, Zur Stratigraphie der Oberen Kreide in den höheren helvetischen Decken: Eclogae geol. Helvetiae, vol. 37, pp. 217–328, pl. 9.

BROTZEN, F., 1936, Foraminiferen aus dem schwedischen untersten Senon von Eriksdal in Schonen: Sveriges geol. undersökning, ser. C, no. 396, Arsbok 30, pp. 1–206, pls. 1–14.

——, 1942, Die Foraminiferengattung *Gavelinella* nov. gen. und die Systematik der Rataliformes: Sveriges geol. undersökning, ser. C, no. 451, Arsbok 36, pp. 1–60, pl. 1.

CITA, M. B., 1948, Ricerche stratigrafiche e micropaleontologiche sul Cretacico e sull'Eocene di Tignale (Lago du Garda): Riv. italiana paleontologia, anno 54, pp. 49–74, 117–133, 143–168, pls. 2–4.

CUSHMAN, J. A., 1940, Foraminifera, their classification and economic use, 3d ed., Cambridge, Harvard Univ. Press.

——, 1946, Upper Cretaceous Foraminifera of the Gulf Coastal region of the United States and adjacent areas: U. S. Geol. Survey Prof. Paper 206.

——, and JARVIS, P. W., 1932, Upper Cretaceous Foraminifera from Trinidad: U. S. Nat. Mus. Proc. vol. 80, art. 14, pp. 1–60, pls. 1–16.

——, and RENZ, H. H., 1947, Further notes on the Cretaceous Foraminifera of Trinidad: Cushman Lab. Foram. Research Contr., vol. 23, pt. 2, pp. 1–42, pls. 1–8.

GANDOLFI, R., 1942, Ricerche micropaleontologiche e stratigrafiche sulla Scaglia e sul Flysch

cretacici dei dintorni di Balerna (Canton Ticino): Riv. italiana paleontologia, anno 48, Memoria IV, pp. 1–160, pls. 1–14.

DE LAPPARENT, J., 1918, Étude lithologique des terrains crétacés de la région d'Hendaye: Carte géol. France Mém., pp. 1–153.

RENZ, O., 1936, Stratigraphische und mikropalaeontologische Untersuchung der Scaglia (Obere Kreide-Tertiär) im zentralen Apennin: Eclogae geol. Helvetiae, vol. 29, pp. 1–149, pls. 1–15.

SIGAL, J., 1948, Notes sur les genres de foraminifères *Rotalipora* Brotzen 1942 et *Thalmanninella:* Rev. d l'Inst. Français du Pétrole et Annales des Combustibles liquides, vol. 3, pp. 95–103, pls. 1–2.

THALMANN, H. E., 1942, *Globotruncana* in the Franciscan limestone, Santa Clara County, California: Geol. Soc. America Bull., vol. 53, p. 1838.

VOGLER, J., 1941, Beiträge zur Geologie von Niederländisch-Indien Ober-Jura und Kreide von Misol: Palaeontographica, supplement, vol. 4, pp. 245–293.

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PENNSYLVANIAN CRINOIDS FROM LAKE BRIDGEPORT, TEXAS

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ABSTRACT—A rich crinoid fauna has been obtained from the Lake Bridgeport shale of Texas. It includes an unusually developed *Delocrinus* and eight new species and two new subspecies. *Tribrachiocrinus* is referred to the Lecanocrinidae.

INTRODUCTION

THE specimens used in this study have been made available to the author mainly by William T. Watkins of San Antonio, Texas. Several important specimens were collected by R. J. Stark of Grapevine, Texas, and one nearly complete crown was found by F. T. Moseley of Dallas, Texas. The stratum from which the specimens were collected is comparable to that described by King (1932):

> The strata from which this fauna (sponges) has been obtained include a yellow sandy limestone approximately 1 foot thick between beds of yellow clays, the entire section being about 20 feet in thickness. This exposure lies in the Brownwood shale about 35 to 55 feet below the Rock Hill limestone of the Graford formation of the Canyon Group (Missouri Series) of north-central Texas.

Mr. Watkins reports that the outcrops 4 miles west of the railroad station at Bridgeport, Wise County, Texas, and 0.01 mile north on the paved road off the Lake Bridgeport Road from where the present assemblage was obtained, consists of variegated shales containing the same sponge fauna referred to and described by King.

In addition to the species described, the following crinoids have been identified in the collections:

Laudonocrinus subsinuatus (Miller & Gurley)
Delocrinus pictus Moore & Plummer
Delocrinus subhemisphericus Moore & Plummer
Endelocrinus tumidus Strimple
Endelocrinus grafordensis Moore & Plummer
Erisocrinus sp.
Athlocrinus sp.
Lecythiocrinus sp. (radial plate only)
Ulocrinus sp. (IBB and portion of BB circlet)
Apographiocrinus typicalis Moore & Plummer
Apographiocrinus cf. *arcuatus* Strimple
Stellarocrinus sp.
Elibatocrinus sp. (IBB circlets only)
Amphicrinus sp.
Delocrinus sp.
Utharocrinus cf. *granulosus* Strimple

SYSTEMATIC DESCRIPTIONS

Genus DELOCRINUS Miller & Gurley, 1890

DELOCRINUS sp.

Plate 36, figures 1–4

Description.—So far as known to the author this is the first record of a crinoid from the Pennsylvanian of North America having an entire ramus suppressed at the level of the radial facets. The right anterior radial of this specimen has no articulating arm facet and its uppermost portion extends upward and curves inward to a solid point. There is no evidence of articulating fossae on this triangular extension of the radial and careful examination discloses no suture between the upper and lower portion of the plate. A solid, well developed anal plate is present in the posterior interradius and there is no question of the identification of this specimen as a bona fide *Delocrinus*.

For somewhat similar development it is necessary to refer to specimens discovered outside the North American continent. James Wright (1936) has described a Scottish species of Lower Carboniferous age as *Tribrachiocrinus caledonicus*, which he referred to that genus with reservation. In this species two rami are suppressed, one in the left anterior and the other in the right posterior ray. Wright reported that in most of his specimens there is a small triangular, "non-arm-bearing brachial" resting on a narrow radial facet but in three specimens he found it impossible to detect a suture between them.[1] This shows fusion of a modified primibrachial with the radial, rather than actual extension of the radial

[1] The author examined these specimens when stationed in Scotland with the U. S. Army and is therefore able to verify Wright's observations.

as is believed to occur in the Pennsylvanian specimen under study. Wright further noted some tendency toward fusion of the basals and possibly also the infrabasals, as well as sharp reduction in the size of the specialized radials. Most of the specimens show five infrabasals, five basals, five radials and three anal plates. All specimens have a deep basal concavity. It is certain that his species is a highly specialized inadunate and probably it should be referred to a new genus.

Tribrachiocrinus M'Coy (1847), as exemplified by the genotype, *T. clarkii* from Australia, differs markedly from the Scottish forms in the following respects: 1) lack of basal concavity, 2) high dorsal cup, 3) presence of only three infrabasals, and 4) the fact that radials of the two non-arm-bearing rays are almost as wide as normal radials.

In the study of an entirely different problem, Dr. R. C. Moore and the author concluded that *Tribrachiocrinus* probably belongs to the Flexibilia rather than the Inadunata. Apparently this specialized trend is not confined to the inadunates.

Several highly specialized forms characterized by simplicity of structure and elimination of various elements occur among late members of the Codiacrinidae Bather (1899) but these are mainly forms which have been generally placed in the Hypocrinidae Jaekel (1918) and they are not related to those under consideration here. It is in the Sundacrinidae Moore & Laudon (1943) that closely similar development is found. *Sundacrinus* Wanner (1916) has two radials which do not bear arms. These are also sharply reduced in size and the posterior interradius is highly unstable in having from three anal plates (normal or primitive type) to only one, the radianal, within the cup. The non-arm-bearing rays are in the right anterior and left anterior positions. *Indocrinus* Wanner (1916) is peculiar in numerous respects and is known to have suppressed the arms of the right anterior and left anterior rays.

It is noteworthy that suppression of arm-bearing rays takes place in the left anterior and right anterior radii first. Studies of the growth stages of allagecrinids show that the first arm facets appear on the right posterior, left anterior and right anterior radial in that order. One would expect the last appearing arm facets in the anterior and left posterior radius to be the first suppressed if this is a regressive process. Because they are not, this is evidently a progressive development.

Material.—One dorsal cup collected by R. J. Stark. To be deposited in the U. S. National Museum.

Occurrence.—Lake Bridgeport shale, Bridgeport, Texas.

Genus GRAPHIOCRINUS de Koninck & Lehon, 1854

GRAPHIOCRINUS BRIDGEPORTENSIS Strimple, n. sp.

Plate 37, figures 9–12

Description.—Dorsal cup rounded, with broad, flat base. Outline evenly circular. Infrabasals five, extending beyond the columnar scar which is depressed. Basals participate in the basal plane and curve upward to form part of lateral walls of cup. Posterior basal truncated and supports a single anal plate. Radials five, pentagonal, slightly wider than high. Articular facets produced inward horizontally. Small prong-like extensions occur at upper junctions of radials but do not extend into the adsutural regions of the arm articulating facets. Muscle fossae well defined. Anal plate hexagonal, extends well above upper limits of cup.

All sutures bordered by weak narrow ridges extending along edges of plates. Surface moderately granular. Arms unknown.

Measurements of holotype in mm:

Greatest width	13.6
Height of dorsal cup	5.5
Width, IBB circlet	3.7
Width, stem impression	2.5
Length, l. ant. B	5.5
Width, l. ant. B	7.0
Length, interbasal suture	3.0
Length, l. ant. R	5.0
Width, l. ant. R	8.7
Length, interradial suture	3.5
Width, cup opening at summit	7.6

Remarks.—This specimen is slightly larger than *G. stantonensis* Strimple (1939) and has a more even outline. The hollow base of *G. kingi* Moore & Plummer (1940) distin-

guishes it from the present species which has a flattened base.

Occurrence.—Lake Bridgeport shale, Bridgeport, Texas.

Holotype.—Collected by W. T. Watkins. To be deposited in the U. S. National Museum.

Genus PIRASOCRINUS Moore & Plummer, 1940

PIRASOCRINUS INVAGINATUS Strimple, n. sp.

Plate 36, figures 8–11; plate 38, figures 5–6

Description.—Dorsal cup very shallow with broadly concave base. Outline pentagonal with anal plates strongly protruding posteriorly. Infrabasals five, slightly larger than circular area of stem attachment. Basals entirely within basal concavity. Notches occur at the summits of the interradial sutures and the outward directed articular facets of the radials do not extend the entire width of these plates. Three normally placed anal plates (primitive type) occupy the depressed posterior interradius and are directed outward. Anal X rests directly on the posterior basal followed by the radianal to the right and the RX above.

All sutures are enclosed between minute ridges along the outer edges of the plates. Surface smooth except for minute granules visible under strong magnification.

Portions of the arms are preserved in the right anterior, anterior, and left anterior rays. The first primibrachials are axillary, low and broad. Subsequent brachials are broad and thin. The fifth or sixth secundibrachials are axillary and produced as spines. About 15 tertibrachials are preserved in several outer and inner arm branches without bifurcation but in the outer right branch of the left anterior arm an axillary tertibrachial is present. So far as preserved the arms are entirely uniserial.

Measurements of holotype and paratype in mm.:

Height, dorsal cup	3.0	2.2
Lateral width	22.6	20.2
Maximum width	—	20.6
Depth, basal concavity	—	1.9
Diameter, stem impression	3.0	2.8
Width, cup opening at summit	—	11.0
Ratio, height to width	13.3 per cent	10.8 per cent

Remarks.—The combination of characters presented by this crinoid is perplexing. The dorsal cup has all of the features of *Sciadiocrinus*. The arms, however, are like those of *Pirasocrinus* which has nonspiniferous primibrachials and spiniferous axillary secundi- and tertibrachials. Perhaps *Sciadiocrinus* should be placed in synonomy of *Pirasocrinus* but this is not recommended at present.

The only described species which closely resembles *S. invaginatus* is *S. acanthophorus* (Meek & Worthen) and the arms of that species are distinctly different. It has a more erect anal series and its plates are thicker those of the present species.

Occurrence.—Lake Bridgeport shale, Bridgeport, Texas.

Types.—Holotype collected by W. T. Watkins; figured paratype collected by R. J. Stark. To be deposited in the U. S. National Museum.

Genus STELLAROCRINUS Strimple, 1940

STELLAROCRINUS TEXANI Strimple n. sp.

Plate 37, figures 13–16

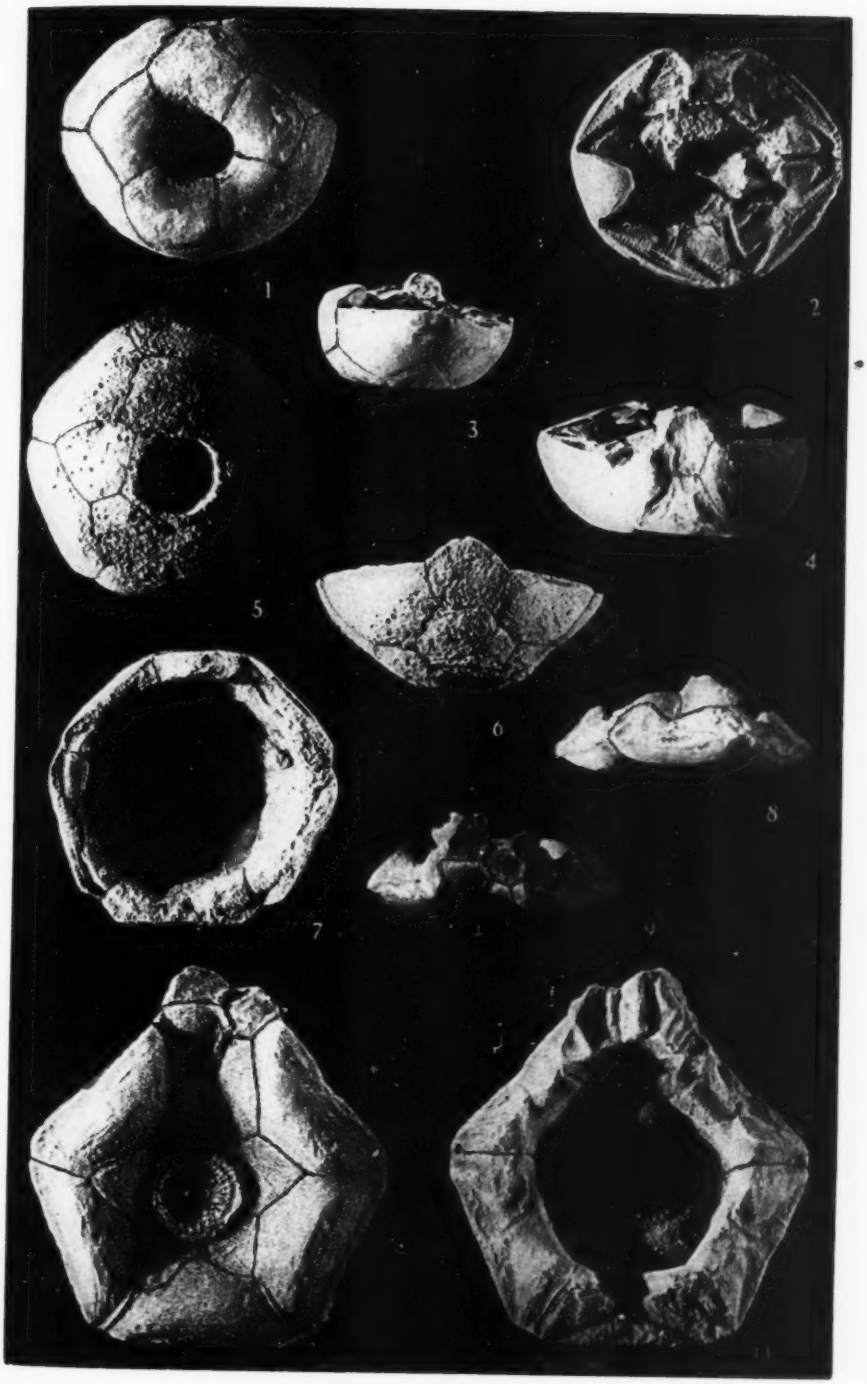
Description.—Dorsal cup rather low with deep basal concavity. Infrabasals five, in a flat plane at the bottom of basal depression whose erect lateral walls are formed by the inner portions of the basals. Basals swollen centrally and bearing elongate nodes from which low ridges extend to adjoining radials.

EXPLANATION OF PLATE 36

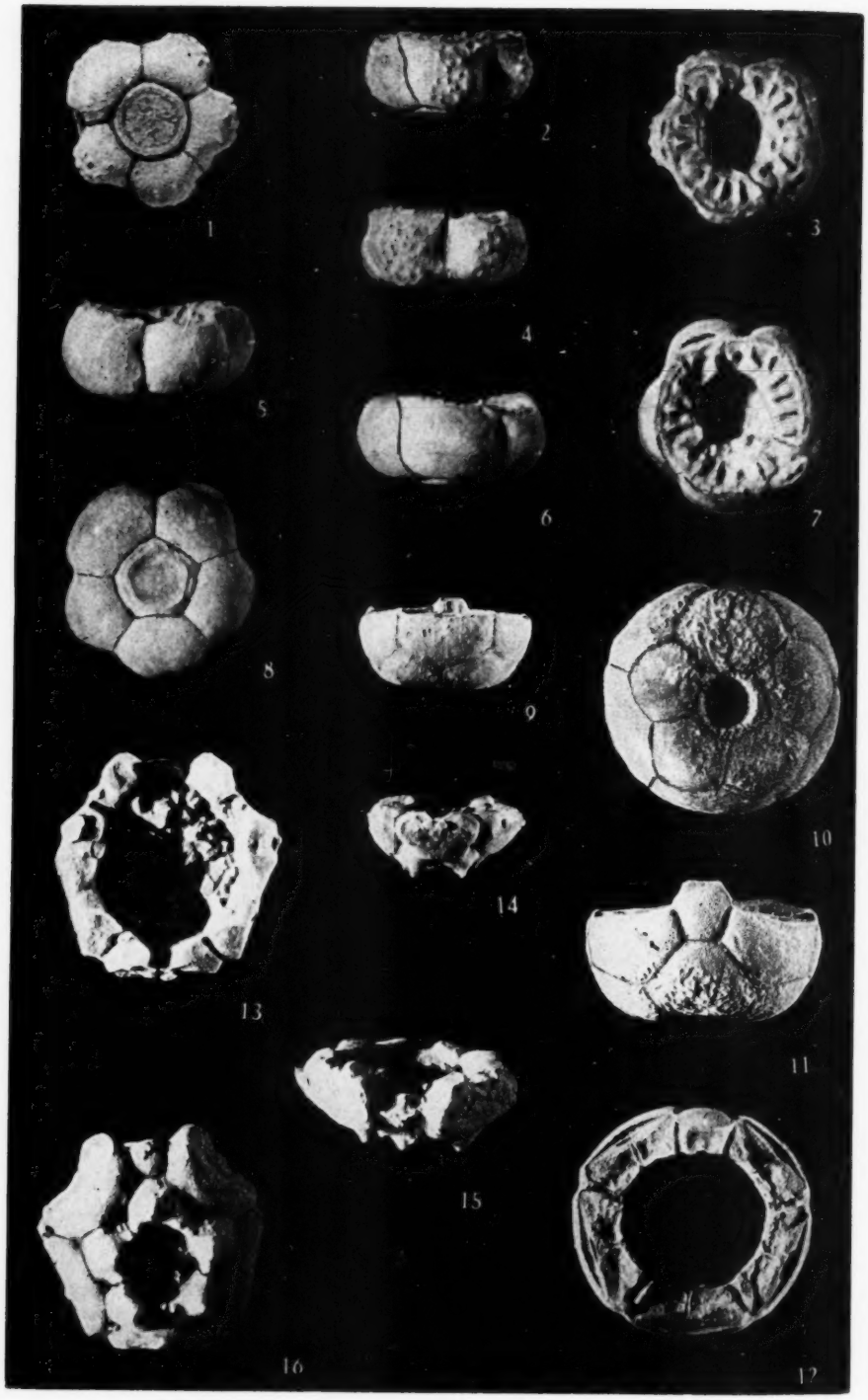
FIGS. *1–4*—*Delocrinus* sp. Dorsal cup from *1*, below, *2*, above, *3*, anterior, and *4*, posterior. Non-arm-bearing radial is right anterior. *1*, *2*, *4*, ×2 3/10; *3*, ×1 3/5. (p. 200)

5–7—*Cibolocrinus erectus* Strimple, n. sp. Holotype, from *5*, below, *6*, posterior, and *7*, above; ×2 3/10. (p. 203)

8–11—*Pirasocrinus invaginatus* Strimple, n. sp. Paratype, from *8*, anterior, *9*, posterior, *10*, below, and *11*, above. *8*, *9*, ×1 3/5; *10*, *11*, ×2 2/5. See also plate 38. (p. 202)



Strimple, Texas Pennsylvanian crinoids



Strimple, Texas Pennsylvanian crinoids

Smaller nodes occur on both sides of the interbasal sutures at the edge of the basal concavity. Radials large, with almost vertical articular facets. One anal plate (probably the radianal) rests upon the truncated posterior basal. Two additional anal plates are present in paratypes but are missing in the holotype. They are approximately equal in size and their uppermost extremities form an even plane.

Columnar scar is round, heavily crenulated, with a minute pentalobate lumen. Entire surface with minute granules visible under moderate magnification. Arms unknown.

Measurements of holotype in mm.:

Height, excluding facets	3.2
Height, including facets	5.0
Width	12.5
Diameter, stem impression	2.3
Depth, basal concavity	1.5
Width, IBB circlet	3.3
Length, r. post. B[2]	4.2
Width, r. post. B[2]	2.8
Length, r. ant. R. excluding facet[2]	3.5
Width, r. ant. R[2]	7.1

Remarks.—This species is readily distinguished from *S. geometricus* (Moore & Plummer) (1940) by its deeper basal concavity and more delicate ornamentation. *S. florealis* (Moore & Plummer) (1940) is somewhat similar but the interbasal sutures are not excavated at the edges of the basal depression and the anal plates occupy a broader area. Among Oklahoma species, *S. distinctus* Strimple (1940b) is similar but the ridges passing from the basals to the radials are stronger and the interbasal sutures are not as deep.

Occurrence.—Lake Bridgeport shale, Bridgeport, Texas.

[2] Measurements along curve of plates.

Types.—Collected by W. T. Watkins. To be deposited in the U. S. National Museum.

Genus Cibolocrinus Weller, 1909
Cibolocrinus erectus
Strimple, n. sp.
Plate 36, figures 5–7

Description.—Dorsal cup flaring evenly upward from the infrabasal circlet, slightly asymmetrical. Three unequal infrabasals visible from the side occupy a pentagonal area with a large shallow depression within which the stem was attached. Basals five, large, hexagonal. Posterior basal supports a single large anal plate which is elongate with uneven upper edges and more or less pentagonal shape. Radials five, pentagonal, with very narrow articular facets.

Measurements of holotype in mm.:

Width	16.1
Height	5.5
Width, IBB disk	6.6
Width, columnar scar	4.0
Length, r. ant. B	5.0
Width, r. ant. B	5.7
Length, interbasal suture	2.2
Width, r. ant. R	9.6
Length, r. ant. R	4.6
Length, interradial suture	2.1
Width, cup opening at summit	11.7

Remarks.—*C. erectus* resembles the Lower Permian *C. regalis* Moore & Plummer (1940) more than any other described species. The latter, however, has infrabasals not visible in side view and a more shallow cup. Some undescribed forms from the Missourian beds of northeastern Oklahoma and southeastern Kansas appear to be closely related to the species under consideration.

This species has notches along interradial sutures at the summit of the cup, a character not observed among Morrowian species of the genus but rather common among Upper Pennsylvanian ones.

Explanation of Plate 37

Figs. *1–4*—*Allagecrinus bassleri nodosus* Strimple, n. subsp. Holotype, from *1*, base, *2*, anterior, *3*, above, and *4*, posterior; ×4 3/10. (p. 204)

5–8—*Allagecrinus bassleri status* Strimple, n. subsp. Holotype, from *5*, posterior. *6*, anterior, *7*, below, and *8*, above; ×4 3/10. (p. 204)

9–12—*Graphiocrinus bridgeportensis* Strimple. n. sp. Holotype. from *9*, anterior, *10*, below, *11*, posterior, and *12*, above. *9*, ×2; *10*, *11*, *12*, ×3 3/10. (p. 201)

13–16—*Stellarocrinus texani* Strimple, n. sp. Holotype, from *13*, above, *14*, anterior, *15*, posterior, and *16*, below. *13*, *15*, *16*, ×2½; *14*, ×1 4/5. (p. 202)

Occurrence.—Lake Bridgeport shale, Bridgeport, Texas.

Types.—Holotype collected by W. T. Watkins. Young paratype collected by R. J. Stark. To be deposited in the U. S. National Museum.

Genus ALLAGECRINUS Carpenter & Etheridge, 1881

ALLAGECRINUS BASSLERI NODOSUS Strimple, n. subsp.

Plate 37, figures 1–4

Description.—Dorsal cup low and broad. Basals barely visible from side, three, unequal, small plate posterior. Radials five, large, swollen, unequal, with clusters of nodes in central parts. Mature specimens have one arm on right posterior and left anterior radials, three on right anterior, four on anterior and five on left posterior radial. Left posterior radial widest, left anterior narrowest. Sutural areas between radials strongly depressed except near the summit of calyx where they may be seen when cup is viewed from below. Left shoulder of right posterior radial is depressed for reception of the single anal plate. Entire surface minutely pitted.

Measurements of holotype in mm.:

Width	5.6
Height	2.4
Width, BB circlet	2.3
Width, columnar scar	1.5
Maximum width, cup opening at summit	2.0

Remarks.—This subspecies resembles large specimens of *A. constellatus* Moore (1940) but the radials are not so angular when viewed from below. The radials of some large specimens of *A. bassleri* Strimple (1938) bear a few nodes but they are not as prominent as in the subspecies. The radials of *A. bassleri* are more swollen but not angular. Unusually large specimens of *A. strimplei* Kirk (1936) have been observed by the author which have large nodes on the radials, but these specimens are much smaller and lower than the present form. *A. kylensis* Strimple (1948) has a more strongly lobed outline and is without nodes.

The arm facets are peculiar in that the inner extremities seem to be separated from the main parts of the radials. This is most readily noticeable where the elongated shoulder of the left posterior radial encroaches on the left anterior radial. When the cup is viewed from the opposite side at a low angle a considerable gap is apparent between the facet and the main underlying part of the radial. Close examination of well preserved specimens from other localities reveals a similar condition although it is less noticeable in most specimens.

Occurrence.—Lake Bridgeport shale, Bridgeport, Texas.

Types.—Collected by W. T Watkins. To be deposited in the U. S. National Museum.

ALLAGECRINUS BASSLERI STATUS Strimple, n. subsp.

Plate 37, figures 5–8

Description.—Dorsal cup low and broad. Basals not visible from side; three, unequal, small plate posterior. Radials five, large, robust, unequal. Right posterior radial with a single arm facet; left side depressed for reception of the anal plate. Right anterior radial large, left shoulder encroaches strongly upon right posterior radial, with four facets. Left anterior radial small, with one arm facet. Left posterior radial with five arm facets, quite large and bulbous appearing.

Surface with fine punctations visible under slight magnification.

Measurements of holotype in mm.:

Width	6.2
Height	2.9
Width, columnar scar	1.8
Diameter, BB circlet	2.2
Maximum width, cup opening at summit	2.6

Remarks.—This subspecies is similar to *A. bassleri* and differs mainly in its more robust form, greater number of arms and thinness of basal disk. It is much more common at the type locality than *A. bassleri nodosus*, which has a higher cup, more prominent ornamentation, and less swollen radials.

Occurrence.—Lake Bridgeport shale, Bridgeport, Texas.

Types.—Collected by W. T. Watkins. To be deposited in the U. S. National Museum.

Genus PERIMESTOCRINUS Moore & Plummer, 1938

PERIMESTOCRINUS MOSELEYI Strimple, n. sp.

Plate 39, figures 5–10

Description.—Dorsal cup shallow, basin shaped. Infrabasals five, small, confined to floor of narrow, deep basal concavity. Basals five, moderately large, with lower portions curving sharply into basal depression. Radials five, wide with outwardly directed articular facets. Three anal plates may occur in normal or in more advanced arrangement. All sutures deeply impressed. Surface coarsely granular.

Arms so far as known uniserial; 30. First primibrachials axillary, rather elongate, each bearing a spine near upper angle. All subsequent brachials much shorter, quadrangular, somewhat tumid, coarsely granular. All axillary brachials spine-bearing. Six secundibrachials in all rays (the sixth being axillary) except in right branches of anterior and left posterior rays which have eight. The holotype has no more than seven tertibrachials preserved in any arm branch. Arms belonging to another individual bifurcate on the eight tertibrachials in outer branches only, the inner ones having as many as 19 or 20 tertibrachials. Outer branches with as many as nine quartibrachials.

Proximal segments of stem thin and circular.

Measurements of holotype and figured paratype in mm.:

Height, dorsal cup	4.5	4.6
Width, dorsal cup	15.2	14.6
Diameter, proximal columnal	2.2	2.0

Remarks.—This species resembles *P. impressus* Moore & Plummer (1940) (from the Mineral Wells formation), as exemplified by the holotype, more than any other that has been described. The dorsal cup designated as the holotype of *P. impressus* is more bulbous and the figured paratype of that species is considerably broader than *P. moseleyi*. Neither of these specimens has the pronounced ornamentation of the new species.

The anal plates of *P. moseleyi* may be normally arranged or somewhat modified. In normal arrangement the anal X rests on the posterior basal, the radianal is in contact with the right posterior basal and the RX plate touches the radianal. This arrangement has been termed "primitive type" by Wright (1926 and 1927) and others. The holotype of *P. moseleyi* has an "advanced type" of arrangement in which the anal X has lost contact with the posterior basal and the radianal has lost contact with the right posterior basal and dominates the posterior interradius.

Occurrence.—Lake Bridgeport shale, Bridgeport, Texas.

Types.—Holotype collected by F. T. Moseley of Dallas, Texas. The two figured paratypes collected by W. T. Watkins. To be deposited in the U. S. National Museum.

Genus PLAXOCRINUS Moore & Plummer, 1938

PLAXOCRINUS LAXUS Strimple, n. sp.

Plate 38, figures 1–2; plate 39, figures 1–2

Description.—Dorsal cup large, broad, shallow, with hexagonal outline which is scalloped by depressions in the upper interradial sutures and the posterior interradius. Basal concavity broad, shallow. Infrabasals and basals five, nearly horizontal. Radials five, with articular facets directed outward. Posterior interradius depressed, containing three large anal plates in normal arrangement (primitive type). Columnar scar is circular, with round lumen surrounded by a raised ridge.

Measurements of holotype in mm.:

Height to outer edges of facets	5.2
Width	26.2
Diameter, columnar scar	3.3

Remarks.—This species resembles *P. perundatus* Moore & Plummer (1940) of the Millsap Lake formation more than any other that has been described. It differs mainly in its more horizontal radials, more depressed posterior interradius and less erect articular facets.

Occurrence.—Lake Bridgeport shale, Bridgeport, Texas.

Type.—Collected by W. T. Watkins. To be deposited in the U. S. National Museum.

PLAXOCRINUS OECONOMICUS
Strimple, n. sp.
Plate 38, figures 7–8

Description.—This species is represented by a nearly complete crown. Unfortunately, the dorsal cup is distorted by compression but it is possible to determine that the basals curve evenly into a shallow basal depression and other general characteristics suggest its generic indentification.

Infrabasals not preserved. Basals five, normal, medium sized. Radials five, large, slightly wider than high. Three anal plates occur in normal arrangement (primitive type). Surface unornamented, plates not tumid, sutures not excavated.

Twenty-one arms are preserved. An outer branch of the right anterior ray bifurcates a third time and probably all outer branches were similarly constructed. Primibrachials axillary, slightly wider than high, with upper portions extending as stout spines. Other brachials wide, low, flattened, moderately cuneiform. Other axillaries not spine-bearing. Secundibrachs six except in left branch of anterior ray which has five. The eighth tertibrachial in an outer branch of the right anterior ray is axillary.

Measurements of holotype in mm.:

Height, dorsal cup, estimated	6.0
Width, estimated	18.5

Remarks.—This species differs from the associated *P. laxus* in lacking the notches between the arm facets and having less tumid radials. Arm structure is distinct from other described species.

Occurrence.—Lake Bridgeport shale, Bridgeport, Texas.

Type.—Collected by W. T. Watkins. To be deposited in U. S. National Museum.

Genus EUONYCHOCRINUS Strimple, 1940

This genus was proposed by Strimple (1940a) for the reception of the new species, *E. dubius* of Missourian age, the genotype. It was listed by Bassler and Moody (1943) but has been neglected by some authors. Probably the lack of complete crowns has prevented its wider recognition. The type of *E. dubius* retains portions of its arms and other species have subsequently been found which substantiate the characterization of this genus.

EUONYCHOCRINUS SUBSERVIRE Strimple, n. sp.
Plate 38, figures 3, 4; plate 39, figures 3, 4, 11

Description.—Dorsal cup small and shallow. Infrabasals three, small, covered by stem externally but clearly apparent internally. Basals five or three, mostly covered by the columnar scar except for posterior which is elongated. Radials five, relatively large, nearly horizontal. Right shoulder of posterior basal supports a small anal plate which is elongated, pentagonal, and does not penetrate to the inside of the cup. It is faceted above for the reception of another small plate of the anal tube. The left shoulder of the posterior basal curves sharply inward and appears to be faceted for the reception of a single tegmen plate which probably extended behind and to the left of the anal series. This arrangement is similar to that of *Onychocrinus* Lyon & Casseday (1860) of Mississippian age.

First primibrachials quadrangular. Second primibrachials axillary. Further branching of the arms is shown by a figured paratype.

Surface of cup and arms coarsely granular, Stem impression round with slightly crenulated perimeter and a minute pentalobate lumen.

Measurements of holotype in mm.:

Width, dorsal cup, estimated	10.7
Height	1.1

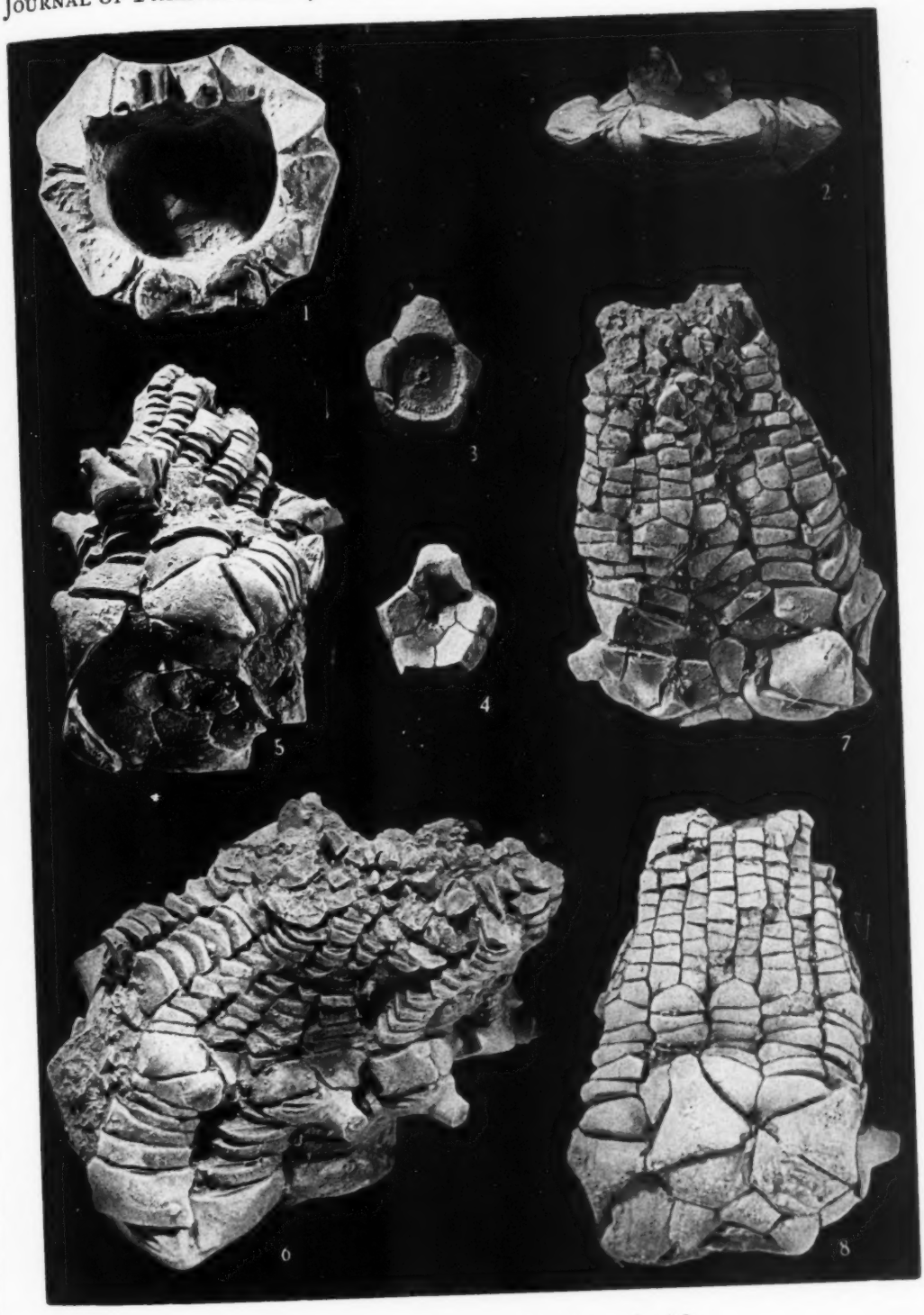
EXPLANATION OF PLATE 38

FIGS. *1–2*—*Plaxocrinus laxus* Strimple, n. sp. Holotype, from *1*, above, and *2*, anterior; ×1 7/10. See also plate 39. (p. 205)

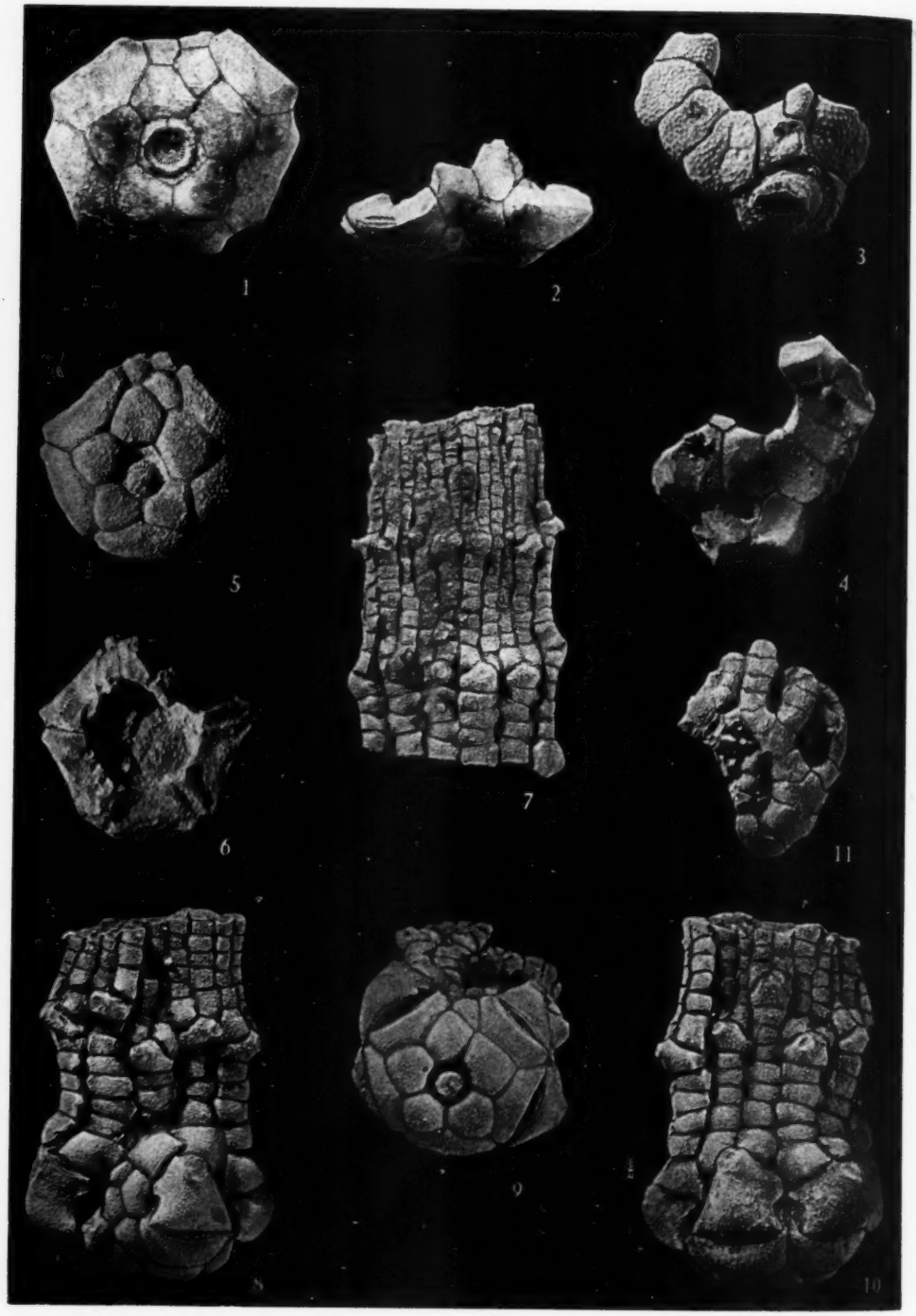
3, 4—*Euonychocrinus subservire* Strimple, n. sp. Paratype (BB circlet), from *3*, below, and *4*, above; ×3. See also plate 39. (p. 206)

5, 6—*Pirasocrinus invaginatus* Strimple, n. sp. Holotype. *5*, Oblique view of crown with posterior interray to the right; ×1 3/10. *6*, View from opposite side; ×1 7/10. See also plate 36. (p. 202)

7, 8—*Plaxocrinus oeconomicus* Strimple, n. sp. Holotype, from *7*, posterior, *8*, anterior; ×1 7/10. (p. 206)



Strimple, Texas Pennsylvanian crinoids



Strimple, Texas Pennsylvanian crinoids

Length, l. post. R.	3.0
Width, l. post. R.	5.8
Diameter, columnar scar	4.2

Occurrence.—Lake Bridgeport shale, Bridgeport; Texas.

Types.—Collected by W. T. Watkins. To be deposited in the U. S. National Museum.

REFERENCES

BATHER, F. A., 1889, A phylogenetic classification of the Pelmatozoa: British Assoc. Adv. Sci. Rept. for 1898, pp. 916–923.

CARPENTER, F. HERBERT, and ETHERIDGE, R., JR., 1881, On *Allagecrinus*, the representative of the Carboniferous limestone series: Annals and Mag. Nat. History, ser. 5, vol. 7, pp. 281–298.

JAEKEL, OTTO, 1918, Phylogenie und system der Pelmatozoen: Palaeont. Zeitschr., Bd. 3. pp. 1–128.

KIRK, EDWIN, 1936, A new *Allagecrinus* from Oklahoma: Washington Acad. Sci. Jour., vol. 26, pp. 162–165.

LYON, SIDNEY S., and CASSEDAY, S. A., 1860, Description of nine new species of Crinoidea from the Subcarboniferous rocks of Indiana and Kentucky: Am. Jour. Sci. and Arts, ser. 2, vol. 29, pp. 68–78.

M'COY, F., 1847, On the fossil botany and zoology of the rock associated with the coal of Australia: Annals and Mag. Nat. Hist., vol. 20, pp. 226–236.

MOORE, RAYMOND C., 1940, Relationship of the family Allagecrinidae with description of new species from Pennsylvanian rocks of Oklahoma and Missouri: Denison Univ. Bull., Jour. Sci. Lab., vol. 35, pp. 55–137.

——, and LAUDON, LOWELL R., 1943, Class Crinoidea. In: Shimer, H. W., and Shrock, R. R., Index fossils of North America, pp. 137–209. Cambridge, The Technology Press, Massachusetts Institute of Technology.

—— and PLUMMER, F. B., 1938, Upper Carboniferous crinoids from the Morrow subseries of Arkansas, Oklahoma and Texas: Denison Univ. Bull., Jour. Sci. Lab., vol. 32, pp. 209–313.

—— & ——, 1940, Crinoids from the Upper Carboniferous and Permian strata in Texas: Univ. Texas Pub. 3945, pp. 9–468.

STRIMPLE, HARRELL L., 1938, A group of crinoids from the Pennsylvanian of northeastern Oklahoma. Privately published, Bartlesville, Oklahoma.

——, 1939, A group of Pennsylvanian crinoids from the vicinity of Bartlesville, Oklahoma: Bull. Am. Paleontology, vol. 26, no. 87.

——, 1940a, Four new crinoid species from the Wewoka formation and two from the Ochelata group: Bull. Am. Paleontology, vol. 25, no. 92.

——, 1940b, *Stellarocrinus*, new name for *Whiteocrinus* Strimple: Bull. Am. Paleontology, vol. 25, no. 92A.

——, 1948, Crinoid studies: Part I, Two new species of *Allagecrinus* from the Pennsylvanian of Kansas and Texas; Part 2, *Apographiocrinus* from the Altamont limestone of Oklahoma: Bull. Am. Paleontology, vol. 32, no. 130.

——, 1949, Crinoid studies: Part 3, *Apographiocrinus arcuatus*, new species from the Missouri series of Oklahoma: Bull. Am. Paleontology, vol. 33, no. 133.

WANNER, JOHANN, 1916, Die permischen Echinodermen von Timor (Tiel I). Paleontologie von Timor, Lief. 6, Tiel II. Stuttgart.

WRIGHT, JAMES, 1926, Notes on the anal plates of *Eupachycrinus calyx* and *Zeacrinus koninckii:* Geol. Mag., vol. 63, pp. 145–164.

——, 1927, Some variations in *Ulocrinus* and *Hydreionocrinus:* Geol. Mag., vol. 64, pp. 353–372.

——, 1936, New Scottish Carboniferous crinoids: Geol. Mag., vol. 73, pp. 385–412.

EXPLANATION OF PLATE 39

FIGS. *1, 2*—*Plaxocrinus laxus* Strimple, n. sp. Holotype, from *1*, below, and *2*, posterior; ×1 7/10. See also plate 38. (p. 205)

3, 4, 11—*Euonychocrinus subservire* Strimple, n. sp. Holotype, *3*, from below, *4*, from above; ×2½. 11, Paratype (separated arms); ×1 7/10. See also plate 38. (p. 206)

5–10—*Perimestocrinus moseleyi* Strimple, n. sp. Paratype, *5*, from below, *6*, from above, *7*, (separated arms) from side. Holotype, from *8*, posterior, *9*, below, and *10*, anterior. ×1 7/10. (p. 205)

JOURNAL OF PALEONTOLOGY, VOL. 25, NO. 2, PP. 208–211, 1 TEXT FIGURE, MARCH 1951

A MODEL OF THE INTERNAL STRUCTURE OF *DISCOCYCLINA* S.S.

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ABSTRACT—The structures of *Discocyclina*, *Aktinocyclina* and *Asterocyclina* are compared and a model of *Discocyclina* is illustrated and described in detail. The new family Asterocyclinidae is proposed.

INTRODUCTION

TWO previous papers of the author (1945a, 1945b) partly deal with the structure of *Discocyclina* s.s., *Aktinocyclina* and *Asterocyclina* and demonstrate the existence of morphological differences between the early ontogenetic stages of microspheric forms of certain *Discocyclina* s.s. and *Asterocyclina* species.

In equatorial sections of species of the type of *Discocyclina papyracea* (Boubée) the juvenarium of the *B* generation consists of a small subcircular first or initial chamber and a spiral nepionic stage, which in a number of steps is preparing the annular growth of the adult test. The nepionic stage of *D. papyracea* (Boubée) was subdivided (1945a, p. 595) into three substages:

(a) short spiral of arcuate chambers,

(b) spiral of tangentially elongate chambers subdivided into chamberlets or secondary chambers, and

(c) spiral of chambers subdivided into chamberlets as in substage *b*, with a tendency to envelop the preceding portion *a* and *b* of the nepiont and thus to become almost annular in its last stage.

The neanic stage is composed of annular chambers which are subdivided into numerous chamberlets. It does not seem possible to subdivide the neanic stage on its morphologic features further into substages.

Equatorial sections of species of the type of *Asterocyclina stellaris* (Brunner) show that the juvenarium of the *B* generation also commences with a small subcircular first chamber. The nepiont, however, differs from that of the *B* generation of *Discocyclina* s.s., for it consists of a short spiral of undivided arcuate chambers without any enveloping tendency during growth. The neanic stage starts with the arrangement of chambers in annular rows. The characteristic structural element of this ontogenetic stage is the arcuate-spatulate-rectangular chamber. The star-like pattern of *Asterocyclina* is formed in the course of the neanic development of the equatorial layer of chambers.

The comparison between the ontogeny of the *B* generations of the two groups indicates that the homolog of the neanic *Asterocyclina* chamber is the annular chamber of *Discocyclina* s.s. Chamberlets occur only in *Discocyclina*. Based on this fundamental morphologic difference, the Discocyclinidae have been divided into two subfamilies (1945b, p. 612), i.e., Discocyclininae and Orbitoclypeinae.

The morphologic resemblance between *Discocyclina* and *Asterocyclina*, however, does not reflect a genetic relationship as could be anticipated from the general aspect of the tests of the two groups, and today we believe that it is justified to establish a separate family, Asterocyclinidae, for *Asterocyclina* and related forms (1945a, pp. 604, 612).

The radiate *Aktinocyclina* (1945b) belongs structurally with *Discocyclina* in spite of its radial ridges and non-alternating equatorial chamberlets.

Apart from the analysis of the *B* generation of *Discocyclina* s.s. and *Asterocyclina*, the complex minute structure of the walls of the equatorial chamberlets was investigated also. The structural features of the walls of *Discocyclina* and other forms have been described and figured in detail (1941, 1942, 1945a, 1945b).

INTERNAL STRUCTURE OF *DISCOCYCLINA* S. S.

In order to arrive at a better understanding of the internal structure of this complex group of orbitoidal Foraminifera, more than 300 oriented thin sections of *D. papyracea* (Boubée), *D. strati-emanuelis* Bronnimann, *D.* aff. *varians* (Kaufmann), *D. augustae* van der Weijden, *D. seunesi* H. Douvillé and additional, not specifically determined species, of *Discocyclina* s.s. from the Eocene of Switzerland, France and Italy were investigated. Based on this detailed study, a model of an ideal *Discocyclina* s.s. was prepared showing all the pertinent structural features. Ironstained specimens of *D. papyracea* and *D. strati-emanuelis*, both from the famous upper Eocene locality of Kressenberg, Bavaria, supplied the best material. The sections are deposited in the Museum of Natural History, Basle, Switzerland, with the exception of some sections of *D. papyracea* which are in the author's private collection.

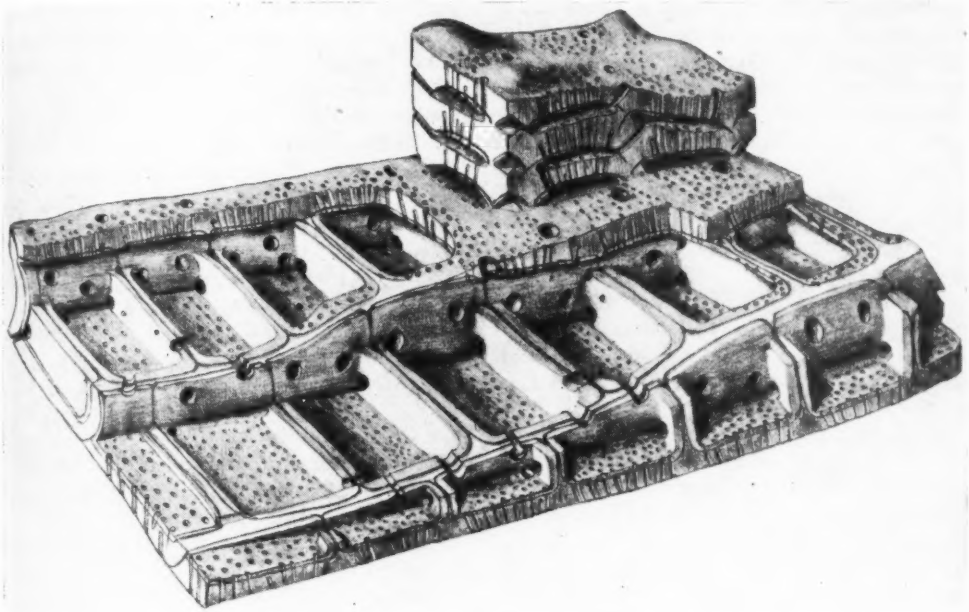

FIG. *1*—Model of the internal structure of *Discocyclina* s.s.

The diagram, figure 1, depicts a portion of the near center equatorial layer of chambers and chamberlets (or equatorial layer) superimposed on the upper right hand side by a few lateral chambers. The model is seen from the periphery of the test. The equatorial layer is represented by two segments of successive annular chambers which are subdivided into alternating chamberlets. The outer segment has been cut obliquely from the roof (right hand side) to the floor of the chamberlets (left hand side). The inner segment has been opened partly by removing the roofs of the chamberlets. The lateral chambers have been cut perpendicularly to the equatorial layer. The surface of the lateral chambers represents a small area of the actual surface of the test. Small pillars are developed and papillae rise slightly above the surface.

The structural elements of the equatorial and lateral layers are the following:

1. EQUATORIAL LAYER

CHAMBERS AND CHAMBERLETS. The term chamber applies 1) to the initial chamber or chambers of the *A* and *B* generations, 2) to the undivided arcuate and to the elongate, subdivided chambers of the

nepiont of the *B* generation, and 3) to the subdivided annular chambers of the neanic stage of the *A* and *B* generations.

The term chamberlet or secondary chamber (Galloway, 1928, 1933) applies only to the subdivisions of the chambers. In the ontogeny of the *B* generation they appear for the first time in the substage *b* of the nepiont (1945a, p. 595).

SEPTAL AND ANNULAR WALL ELEMENTS.—Sections through the walls exhibit, under suitable magnification, a system of dark lines, which are nothing else but the cross-sections of fissural, interseptal lumina between wall layers supplied by adjacent chamberlets. These interseptal lumina are not to be confounded with the true interseptal canal system (marginal plexus) of nummulitids (Vaughan, 1945, p. 52). The width of the dark lines, especially in the radial septa, varies considerably according to the changing development of the interseptal space.

The examination of the arrangement of these lines in sections of ironstained specimens proves clearly that the walls are composed of thin lamellae, differentiated in septal and annular wall elements.

a. Septal wall element.—The thin walls which appear to completely surround each chamberlet form the septal wall element. The existence of these walls was clearly recognized, excepting the very thin layers forming the roofs and the floors of chamberlets. However, it appears in thin sections of well preserved specimens that these thin septal lamellae exist. Their investigation is rendered extremely difficult by the numerous cribriform perforations through the roofs and floors of the chamberlets. The thickness of these layers has been much exaggerated in the accompanying diagram. Radial septa are a formation of the septal wall element. They consist of two lamellae supplied by adjoining chamberlets and are separated by interseptal lumina.

b. Annular wall element.—The annular wall element envelopes all the chamberlets of a chamber. It is a comparatively thick layer with signs of secondary growth and covers the relatively thin walled roofs, floors, and frontal portions of the chamberlets.

In horizontal sections, the annular wall element is the intermediate thick wall between the septal layers of the chamberlets of two adjacent annuli. Two more or less parallel dark lines are cross-sections of interseptal lumina separating three layers: 1) the distal thin lamellae of the chamberlets of the inner annulus, 2) the intermediate thick wall of the annulus, and 3) the proximal thin lamellae of the chamberlets of the outer annulus.

This arrangement is excellently figured by Vaughan (1945, pl. 20, figs. 2a, b), showing the horizontal section of *D.* (*Discocyclina*) *anconensis* Barker from the Murphy's member of the Upper Scotland formation of Barbados. The three lamellae with the interseptal lumina are clearly visible in the upper left hand corner of figure 2a. The *y*-shaped forks at the distal ends of the radial septa (Vaughan, 1945, p. 52) are produced by the interseptal lumina surrounding two adjacent chamberlets. No differentiation is made here between the interseptal spaces of the radial septa and those along the annular wall elements since both represent the same system of interseptal lumina.

COMMUNICATIONS.

a. Radial stolons.—Radial stolons connect the usually alternating chamberlets of adjacent annuli. Two, exceptionally three, radial stolons are developed, and in peripheral annuli up to four or more stolons penetrate the frontal portions of the chamberlets. The radial stolons lie in different levels, and it appears that their number depends on the height of the chamberlet.

b. Annular stolons.—Annular stolons connect the chamberlets of the same annulus. In pairs they penetrate each radial septum proximally, one above the floor, the other below the roof of the chamberlet. Each chamberlet therefore possesses four annular stolons. This number appears to be constant during ontogeny. However, additional but irregularly arranged communications between the chamberlets of the same annulus, often comparable in size with the annular stolons, can be observed. Frequently a single large additional annular stolon penetrates the radial septum near the frontal portion of the chamberlet.

c. Vertical stolons.—Vertical stolons connect the chamberlets with the lateral chambers. They are easily distinguishable from

the small cribriform perforations of the roofs and floors of the chamberlets. Vertical stolons can best be observed in vertical sections parallel to the radial septa. From the annular stolon they usually extend somewhat obliquely upward into the lateral chambers. Additional vertical stolons can occur. The vertical stolons are a normal feature of typical *Discocyclina*. We agree with Vaughan (1945, p. 53) that they are morphologically equivalent to the radial and annular stolons.

d. Perforations.—The lateral perforations are very fine openings piercing the roofs and floors of the chamberlets in great number. They are evenly distributed, and in obliquely cut thin sections they are seen to be more or less confined to the roofs and floors of the chamberlets.

2. LATERAL LAYERS

The lateral layers of chambers cover the equatorial layer on both sides. The lateral chambers produce in their totality the well known lenticular test of *Discocyclina* s.s. Considering the asymmetrical arrangement of the lateral chambers, their structure is principally identical with that of the equatorial chambers and chamberlets.

WALL ELEMENTS.—Two wall elements are distinguished, 1) a thin inner wall corresponding to the septal wall element of the chamberlets, and 2) a much thicker outer layer with signs of secondary growth which can be regarded as the structural equivalent of the annular wall element of the equatorial chamber.

COMMUNICATIONS.—Lateral chambers communicate by large oblique stolons and by small perforations penetrating the roofs of the chambers in great numbers.

PILLARS.—Pillars are developed at the intersections of the walls of the lateral chambers.

CANAL SYSTEM AND INTERSEPTAL LUMINA

Oblique sections and vertical sections parallel to the annuli of *Discocyclina* s.s. show clearly that the "dark lines" are a system of fissural interseptal spaces and not true canals (p. 210). The interseptal lumina are continuous spaces between the septal and annular wall elements and no canals of rounded cross-section have been observed. The term canal system should be reserved for a system of true canals as developed in the nummulites. Rozlozsnik (1927) figured and described in detail slightly oblique equatorial sections of *N. subplanata* Hantken & Madarasz (p. 43, fig. 3) and of *N.* cf. *variolarius* Lamarck (p. 44, fig. 4, p. 48, fig. 8) which exhibit distinctly branching canals within the septa and within the marginal plexus. This morphological difference between the fissural interseptal lumina of *Discocyclina* and the canals of nummulites does not support Vaughan's suggestion (1945, p. 52) that "the annular canals (of *Discocyclina*) are the morphological representation of the canals in the marginal plexus of the Camerinidae." Hence it appears doubtful that there exists a phylogenetic relationship between the nummulites and *Discocyclina*.

REFERENCES

BRONNIMANN, P., 1941, Eine *Discocyclina* mit multilocularem Embryonalapparat aus dem Eocaen von Kressenberg: Eclogae geol. Helvetiae, vol. 34, pp. 305–318.

——, 1942, Eine *Proporocyclina* aus dem Eocaen von Venezuela: Schweizer. Palaeont. Gesell. Abh., vol. 63, pp. 1–17.

——, 1945a, Zur Frage der verwandtschaftlichen Beziehungen zwischen *Discocyclina* s. s. und *Asterocyclina:* Eclogae geol. Helvetiae, vol. 38, pp. 579–615.

——, 1945b, Zur Morphologie von *Aktinocyclina* Guembel 1868: Eclogae geol. Helvetiae, vol. 38, pp. 560–578.

GALLOWAY, J. J., 1928, A revision of the family Orbitoididae: Jour. Paleontology, vol. 2, pp. 45–69.

——, 1933, A manual of Foraminifera. Bloomington, Indiana, The Principia Press.

ROZLOZSNIK, P., 1927, Einleitung in das Studium der Nummulinen und Assilinen: Mitt. Jahrb. K. Ung. Geol. Anstalt, Band 26, Heft, 1, pp. 1–154.

VAUGHAN, T. W., 1945, American Paleocene and Eocene larger Foraminifera: Geol. Soc. America Mem. 9.

——, and COLE, W. S., 1940, Discocyclinidae. In: Cushman, J. A., Foraminifera: their classification and economic use. 3d ed., Cambridge, Harvard Univ. Press.

——, and ——, 1941, Preliminary report on the Cretaceous and Tertiary larger Foraminifera of Trinidad, B. W. I.: Geol. Soc. America Spec. Paper 30.

——, and ——, 1948, Discocyclinidae. In: Cushman, J. A., Foraminifera: their classification and economic use. 4th ed., Cambridge, Harvard Univ. Press.

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RELATIVE GROWTH IN PALEONTOLOGICAL STUDIES

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ABSTRACT—Publication of a rather extensive series of papers on relative growth during the past two decades has shown the need of a formal approach to this subject as it concerns the materials of paleontology. Fossil samples representing growth series may be detected and evaluated through comparisons with properly selected samples from modern populations. The fossil samples may then be studied by a four point approach to analysis, comparison and interpretation based upon analysis of variance. Analytical studies that treat the totality of measurements may be applied to growth series by methods of multiple and partial correlation and the use of discriminant functions.

GENERAL CONSIDERATIONS

SINCE the publication of "Problems of relative growth" by Julian Huxley (1932), a rather extensive series of articles on various aspects of the subject has appeared. A few of these have been devoted to studies of fossils, for example, Hersch (1934), Robb (1935), Phleger and Putnam (1942) and Gray (1946). Although it has been suggested in these paleontological papers, in one way or another, that relative growth of two or more parts of the skeleton might be used as a character of a species or larger taxonomic unit, few of the papers are sufficiently rigorous in their treatment of the data to foster confidence in their results. Reeve (1940, 1941) in a study of modern anteaters, however, has presented a careful treatment of relative growth in taxonomic work. The methods used by Reeve and the approach outlined in the present paper, although developed independently, have many features in common, for both depend upon studies of regression lines based on analysis of variance and employ techniques presented in various books on statistics, particularly Tippett (1945), Fisher (1946) and Snedecor (1946).

The methods presented later in this paper were designed primarily for studies on fossil vertebrate animals, particularly amphibians and reptiles, but may, of course, be applied to any living or fossil organisms for which samples of growth series may be obtained. The procedures have been designed to be as economical of time and effort as is possible in view of the necessarily lengthy calculations that are involved in analyses of regression lines.

Much of the work on relative growth of skeletal parts of animals has been based on the assumption that the relative change of two parts is well expressed by the allometric equation $y=bx^k$. The meaning of this equation has been rather fully investigated by Huxley (1932), Richards (1936), Reeve (1940), Feller (1940), Lumer (1942), and others. It has been found, in studies of samples of fossil reptiles and amphibians currently being conducted by the writers, that the relative growth patterns in the majority of cases are expressed equally well, in many instances better, by the expression $y=a+bx$. It is usually not possible, with the material available, to demonstrate a significant departure of the regressions of pairs of measurements from a straight line on arithmetic coordinates. Even in cases in which the value of k is as low as 0.75 or as high as 1.25, tests may fail to demonstrate that a better fit is accomplished by using the allometric equation. In such studies, therefore, a test for linearity assumes importance in defining the probable form of the relationships to be tested.

The concept that patterns of relative growth may be considered as biological group characters apparently has not been widely recognized among paleontologists, for relatively little paleontological literature is concerned with relative growth even though many problems that are treated show a real need of this approach. Any morphological stage of development, including the adult stage, is in final analysis a product of relative growth, and any proportional studies, concerned with a single stage or with many stages, are in this sense treat-

ing relative growth. Studies of ratios, frequently used to reduce the effects of size differences, in many instances fall into this category. As pointed out by Simpson and Roe (1939), confidence in results obtained by comparisons of ratios is based upon the assumption that the form of equation for the pairs of values is $y=bx$, i.e., the regression line passes through the point $x=0$, $y=0$. This relationship is reasonably closely approached in only about 15 per cent of nearly 100 regressions analyzed in the present studies by the writers. For this reason, it is preferable to use regression methods such as those outlined later in the present paper where growing parts are involved and an adequate sample can be obtained. This is particularly important in studies of such animals as fish, amphibians, reptiles and many invertebrates in which there tends to be no definite limit of growth and, unless a frequency distribution can be established, there may be no basis for accurate judgment concerning the stage of development reached by individuals that make up the sample.

Proper use of relative growth as a group character can prove most helpful in taxonomic studies as shown by Reeve (1940, 1941). The concept has been applied with success by the senior author in studies on *Diplocaulus* and *Trimerorhachis*, fossil amphibians from the Permian, and on various genera and species of the suborder Captorhinomorpha, primitive reptiles, in work now in progress. It must be made clear, however, that such studies are not applicable to all types of characters and by no means offer a panacea for taxonomic difficulties. Some patterns of relative growth appear to have use in differentiation of species whereas others may extend broadly through categories as large as suborders. It has been found, for example, that a series of relative growth relationships persists throughout the suborder Captorhinomorpha, so far as the the small size of samples of some genera permits interpretation, and that a similar but somewhat modified pattern occurs in primitive Pelycosauria, derived, in all probability, from a stock common to both groups. Not only are similarities apparent but divergences may be seen and evaluated both as to direction and amount. Through this type of analysis, it is believed, additional insight into evolution may be gained by broadening the nature of characters studied and by taking into consideration not only one stage, such as the adult, but at least a reasonably extended series of stages of relative growth.

These general remarks might be extended broadly to include such matters as changes of relative growth patterns during ontogeny, the biological meanings of the regression coefficients, the effects of sample size, and others. Each of these problems, however, in last analysis becomes one for interpretation by the investigator as it applies to his particular problems. Furthermore, each has been considered, in one form or another, in the various references cited earlier in this paper. One item, however, demands more specific attention, i.e., the determination of whether or not a sample of fossil organisms constitutes a growth series suitable for treatment by the procedures outlined in later pages of this paper.

FOSSIL SAMPLES OF GROWTH SERIES

Basic to studies of fossil growth series is the ability to recognize whether or not a particular sample or a series of samples represent such a series. As a rule, a sample of a species collected over a limited vertical and lateral range and having a moderate spread in a linear measurement, such as body length or skull length, may safely be considered to represent a growth series. Since, however, several factors may introduce uncertainties a means of evaluation is desirable. Among items that have led to confusion, the fact that proportions tend to change with change of size is important. Proportional differences between large and small members of growth series have not infrequently been used as a basis for specific differentiation. Also confusing is the fact that approximately similar proportional changes occur in phylogenetic and ontogenetic series. In addition, complete or nearly complete discontinuities tend to appear in frequency distributions of samples of growth series and thus lead the investigator to conclude that he is dealing with separate taxonomic units.

Comparisons of samples of fossils with samples obtained from living organisms seem to offer the most profitable means of evaluation. These have been found to be of

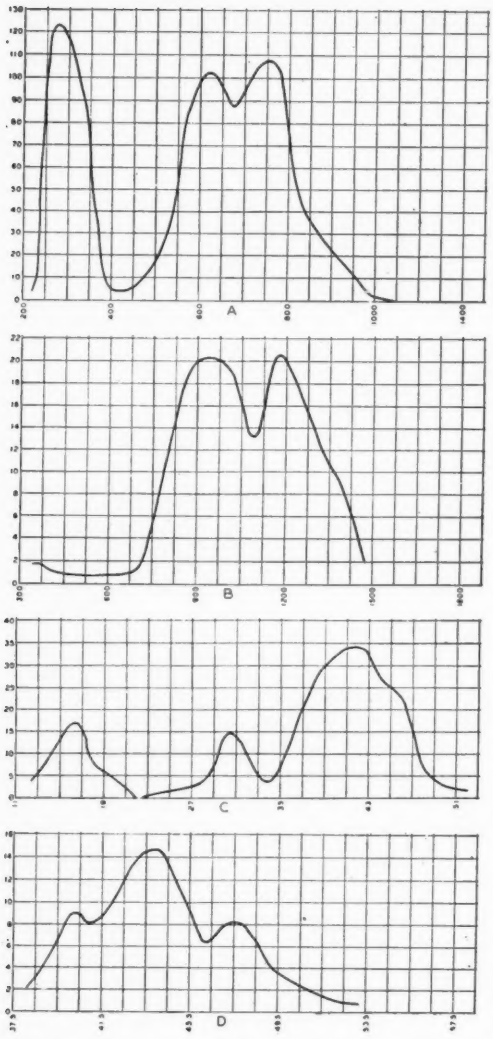

FIG. 1—Curves based on frequency distributions of samples of growth series of modern amphibians and reptiles. Linear measurements plotted on abscissa and frequency on ordinate. Measurements in millimeters.

A. *Crotalus viridis viridis*. (data from Klauber, 1937). Based on total length. $N=858$. Adults: $N=606$, $M=700.6\pm4.2$, $\sigma=104\pm2.9$, includes ♂ and ♀. Class interval = 50 mm. Collected in October except for a few specimens collected in April.

B. *Colubra constrictor*. Based on total length. *OR* = 340–1430. $N=153$. Adults: $N=147$, $M=1067.4\pm15.6$, $\sigma=188.5\pm11.0$, includes ♂ and ♀. Class interval 75 mm. Collected in springs of 1935, 36, 37, 38, 41, 42, 48.

C. *Staurois natator*. Based on snout-vent length. *OR* = 11–52. $N=242$. Adults: $N=170$, $M=41.7\pm.29$, $\sigma=3.77\pm.20$, includes ♂ and ♀. Class interval = 2 mm. Collected on Mindanao island.

D. *Kaloula picta*. Based on snout-vent length. No young of year included. *OR* 38–53. $N=111$, $M=44\pm.49$, $\sigma=3.28\pm.35$, includes ♂ and ♀. Class interval = 1 mm. Collected on Cuyo island.

real value in cases in which it is possible to determine that the fossil and living groups have reasonable similarity in their modes of growth and in which sampling techniques have been designed to produce comparable samples. It is probable that general similarity in modes of growth may be assumed when the living and fossil samples have been drawn from populations that are generally comparable in major taxonomic position and in which the size discrepancies between the two groups are not excessive. The problem of commensurate sampling techniques is less simple. It is essential, of course, that strict adherence to random sampling be maintained for both the recent and fossil organisms. In addition, however, it is necessary to ascertain, within broad limits, how the fossils were accumulated; whether, for example, burial was continuous throughout the year or restricted to intermittent short periods so that one or several size groups, rather than a continuous series, were preserved. The decision on such matters has a bearing on the nature of recent samples to be used for comparison. Fortunately, for all these factors, limits that materially affect results appear to be wide, so that the evidence concerning the biological nature and the conditions of deposition of fossils necessary for analysis usually can be obtained by careful study.

A specific approach to this problem, made in the course of study of Permian amphibians and reptiles, illustrates the method. Samples of Permian vertebrates, *Diplocaulus magnicornis*, *Trimerorhachis insignis*, *Lysorophus tricarinatus* (amphibians) and *Captorhinus aguti* (a reptile) were used. For comparison, analyses of four samples of modern animals, *Kaloula picta*, *Staurois natator* (amphibians), *Colubra constrictor* and *Crotalus viridis viridis* (reptiles), were made. Specimens for the first three modern groups were kindly supplied by Robert Inger of the Chicago Natural History Museum. Data

for the last were obtained from a publication of Klauber (1937). Additional samples of fossil and recent populations have been studied, but these eight suffice for illustration.

Measurements on the modern specimens are either total length or snout-vent length. For three of the fossil groups, skull length has been used. These dimensions increase at about the same rate in individuals in the majority of amphibians and reptiles. For *Lysorophus tricarinatus* the greatest length of the centrum was taken. The values used for the majority of specimens of this species represent the mean of measurements on five or more vertebra. Central length is a good index of trunk length, in this instance, since this dimension varies but little from the axis to the caudal vertebrae (V, the coefficient of variability, in several specimens with ten or more articulated vertebrae was found to be between 0.5 and 2.5). Use of the various measurements cited above should produce similar patterns if the nature of growth in the different samples was similar and the sampling was properly conducted.

Field observations point strongly toward seasonal deposition in the cases of three of the four fossil samples, the case of *Captorhinus aguti* being less certain, as explained below. Therefore, modern samples that were collected over a relatively short period in one year or over the same period in several years were used for comparison. Curves based on frequency distributions of the linear measures are shown in figure 1. Class intervals suitable to each group were used, amounting to about $\frac{1}{2}\sigma$ or $\frac{1}{3}\sigma$ of the distribution, neglecting the pronounced mode in the smallest size groups where this is present. A trimodal curve is shown in figures 1A and 1C (also in 1D, considered below as a different case). The strong mode in the small classes represents the young of the year. The bimodality of the larger classes represents a second year group and a third year group plus all older specimens. The curve in figure 1B is similar except that very few young are included. The curve in figure 1D is trimodal but differs from 1A and 1C in that no young of the year are included. Data are not sufficient to interpret this curve certainly. Probably the mode farthest to the right represents a fourth year group. The possibility that such trimodality results from sexual dimorphism cannot, however, be dismissed.

TABLE 1

Plethodon glutinosus (after Pope and Pope)

Sex	N	M	N	M	σ
Males	25	62 ± 1.14	32	$62 \pm .66$	$3.74 \pm .47$
Females	15	66 ± 1.50	25	66 ± 1.02	$5.08 \pm .72$

Colubra constrictor

Sex	N	M	σ
Males	86	1044 ± 20.4	189.0 ± 14.4
Females	61	1093 ± 24.2	189.5 ± 17.2

Pope and Pope (1949) have presented data on sexual dimorphism and size in the slimy salamander, *Plethodon glutinosus*. Their results, plus σ calculated by the writers on the basis of a different number of specimens, are shown in table 1. Included in the table is a similar analysis of *Colubra constrictor*.

The difference of means of *Plethodon glutinosus* (based on N, M and σ used by the writers) is considered significant ($P<0.01$), but that for *Colubra* constrictor ($P>0.10$) is not. It is not improbable, therefore, that sufficient differences characterize the sexes of some species to produce bimodality in curves based on length, or a related measure, in adults. In the two cases cited in table 1 the percentage of males is 56 for *Colubra*

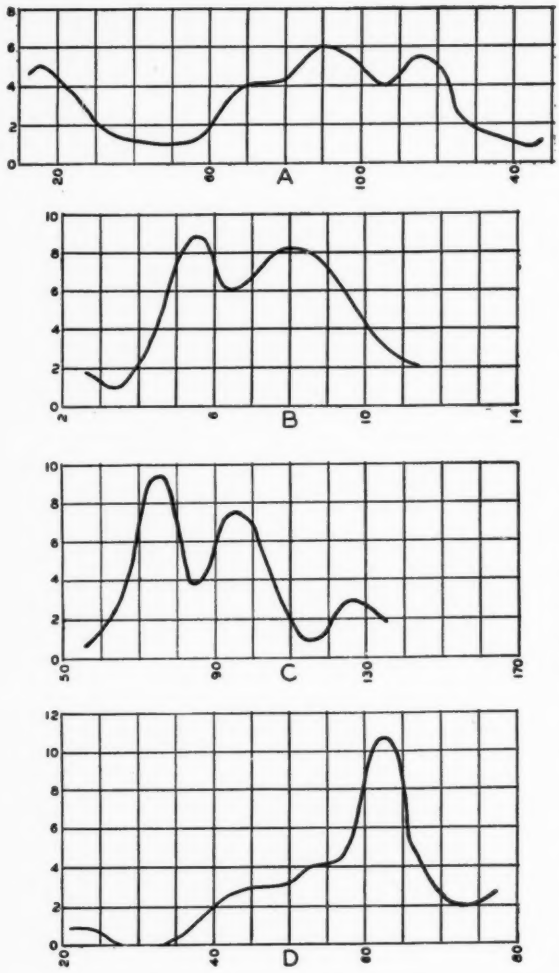

FIG. 2—Curves based on frequency distribution of samples of growth series of three Permian amphibians and one reptile. Linear dimensions on abscissa and frequency on ordinate. Measurements in millimeters.

A. *Diplocaulus magnicornis*. Arroyo formation. Based on skull length. $N=46$. $OR=13-147$. Adults (60 mm. or more): $N=35$, $M=93.1\pm3.5$, $\sigma=20.8\pm2.5$. Class interval = 10 mm. From clay and silt deposits of Baylor and Wilbarger Counties, Texas.

B. *Lysorophus tricarinatus*. Vale formation. Based on mean central length. No young of year included. $OR=2.5-12.5$. $N=51$, $M=7.6\pm.30$, $\sigma=2.14\pm.21$. Class interval = 1 mm. From clays in Knox County, Texas.

C. *Trimerorhachis insignis*. Admiral and Belle Plains formations. Based on skull length. No young of year included. $OR=55-139$. $N=36$, $M=97.5\pm3.4$, $\sigma=20.2\pm2.4$. Class interval = 10 mm. Largely from clays and silts of Archer and Baylor Counties, Texas. Majority of specimens from two local concentrations, one Admiral and one Belle Plains.

D. *Captorhinus aguti*. Belle Plains, Clyde and Arroyo formations. Based on skull length. $OR=21-79$. $N=36$, $M=60\pm1.9$, $\sigma=11.8\pm1.4$. Class interval = 5 mm. From clays, silts, sands and fine conglomerates of Archer, Baylor and Wilbarger Counties, Texas.

constrictor and 59 for *Plethodon glutinosus*, and if this be considered representative, the two modes would be of roughly equivalent height. There is, however, a rather wide range of sex ratios so that a curve like that in 1D might result from sexual dimorphism.

Frequency distributions for the four samples of fossil species are illustrated in figure 2. Comparisons of the curves with those in figure 1 show rather striking resemblances considering that sampling differences are probably rather great. The curve shown in 2A represents *Diplocaulus magnicornis*. There is a marked similarity between this curve and that shown in figure 1A, which suggests that young of the year (so far as the metamorphosed stage is concerned) are present. This is the only fossil sample studied that suggests the presence of this group. It would seem logical to suppose that very small forms would normally not be well preserved because of poor ossification. In the case of *Diplocaulus magnicornis*, however, ossification is highly developed even in very small skulls and the chances of preservation are enhanced by the fact that this species is found in fine-grained silt or, in many instances, in clay. The curve for *Lysorophus tricarinatus* (fig. 2B) resembles those representing the two larger groups of classes in figures 1A and 1B and is different from that of the two larger classes in 1C only in relative height of the modes. The curve of *Trimerorhachis insignis* (fig. 2C) is closest to 1D and resembles it except for the relative height of the modes. No metamorphosed first year specimens are included, but perhaps there is a fourth year group. The curve for *Captorhinus aguti* (fig. 2D) shows less resemblance to any in figure 1. There is only a faint suggestion of bimodality in the strong peak. One first year specimen may be included. This sample, as mentioned earlier, is the one least likely to have resulted from seasonal deposition. The animal was a small, active lizard-like creature,

certainly terrestrial in habit. It does not occur in concentrations as do the others. Since preservation in such cases affects each individual differently, rather than having a common effect on all size groups as in the case of pond accumulation, chances for preservation of increased percentages of the largest and most fully ossified individuals would seem to be increased. Also, where there is no concentration, the collector is likely to find a higher percentage of large, well preserved specimens. It is believed that these factors have contributed to the nature of the sample. This example is included to indicate the sort of variables that may enter into sample analysis and the caution that must be exercised in making interpretations.

For each case presented there seems to be ample support for the original hypothesis that the fossils represent growth series. Similar tests, shaped to meet the conditions of each problem, should be carried out on fossil materials to be studied as growth series.

A word of caution concerning possible over-extension of the method is in order. It is a simple and, at first glance, logical step to apply this approach to taxonomic differentiation. This is a dangerous procedure, although with proper safeguards it may be of value in some cases. A composite sample consisting of two species which attain about the same maximum size will yield much the same sort of curve as will a sample of either species, provided the growth patterns of the pooled samples are comparable. Furthermore, a composite sample consisting of a small and a large species, in which adults alone are present, may give a pattern not unlike that of figures 1A or 1B. If two growth series of moderately different size ranges are combined, however, the composite nature of the sample is made evident by frequency distributions. This method is not designed for taxonomic separation, but to test whether or not study of a sample or samples through analysis of relative growth may be applied usefully.

TREATMENT OF SAMPLES

When it has been determined that the samples to be analyzed are suitable for studies based on relative growth, the procedures outlined in this section may be applied. Two general types of investigation are especially aided by this approach. One is concerned primarily with the separation of small taxonomic units, i.e., mostly species of a single genus. Although the illustrative samples cited in the preceding section consist of specimens of known specific reference, closely allied species, and in some instances genera, tend to produce much the same patterns of frequency distribution when pooled in a single composite sample, and further analyses are necessary for differentiation. A study involving determination of species by the methods outlined here has been made on samples of the genus *Trimerorhachis;* in fact, the sample of *T. insignis* illustrated in figure 2C was differentiated by this means. Specimens for this study were collected from seven early Permian formations. The hypothesis set up and tested was that different species occur in different stratigraphic zones and therefore several successive stratigraphic samples were analyzed. The results of this study will be published in a forthcoming paper, one of a series on the fauna of the Vale and Choza formations of Texas.

The other type of investigation deals with units of known taxonomic composition. The primary purpose is to determine in what ways groups studied are similar and the nature of their differences as shown in the patterns of relative growth. Such a study has been made of the Captorhinomorpha and the samples used consist of species of the various genera of this suborder. Such a study appears useful in a comparison of higher taxonomic categories.

The precise method of approach must be designed to fit the particular problem, especially with respect to selection of samples, but in general the four step analysis outlined below should be followed. It has been found to be the most economical order of procedure of any that the writers have tried. The steps are as follows:

1. Mensuration
2. Selection of relationships to be analyzed
3. Comparison of regression lines
4. Interpretation

Mensuration

The fundamental problem of what to measure arises in the first steps of the application of biometry to systematics. If the aim of the investigator is to be as objective as possible in statistical treatment, a contradiction is immediately introduced when a subjective selection of a few measurements that are considered important is made from a large number of possible measurements. Since, however, the possible number may approach infinity some method of reduction must be sought. Most investigators, consciously or otherwise, select measurements which seem to bear on one or more hypotheses concerning the organisms with which they are dealing. This sort of procedure has the effect of limiting the number of measurements systematically and is logical. The best approximation of total coverage of measurements, however, is to make as many different measurements as can be devised, avoiding only those that are nonsensical in terms of the problem at hand. It must, of course, be realized that any limitation in the number or type of measurements establishes a frame of reference within which all subsequent work and all conclusions are cast.

Not infrequently the number of possible measurements in paleontological studies is limited by the nature of the materials. Even in such cases, however, the number of logical measurements may be excessive in terms of the work necessary for complete analysis. If the labor of analysis is not to be out of all proportion to the results expected, methods to determine which relationships are to be analyzed must be applied. Step 2 is devoted to this procedure.

Selection of relationships to be analyzed

Any large number of measurements of an organism should reveal an underlying order that could be equally well expressed by a much smaller number of basic measurements. The following considerations are important. If several measures show an exceptionally high correlation, any one of these can serve to represent them all. Also, linear dependence may relate a substantial number of measures, i.e., if one linear measure includes a second as a fraction of itself the one is a function of the other.

By a series of reductions, based in part on the above considerations, Thurstone (1947) developed a technique for reducing a large number of variables to basic factors that are independent of each other in the sense that one cannot be predicted from any other by use of a regression equation. As a whole, these factors indicate the underlying order of the original large number of measures. Each embodies contributions from groups of highly related measures and represents that which is common to all members of its group. From an ontogenetic viewpoint these factors may be interpreted on the basis of physiology, embryology and genetics. From a phylogenetic viewpoint, however, it is essentially the changes shown by these basic groupings or statistical factors that delineate the external, morphological expression of evolution. The practicability of such an approach in paleontology is, of course, based on the fact that the materials of the paleontologist, the hard parts of organisms, are well suited for measurement. The junior author has nearly completed a study that seems to demonstrate the efficacy of such an investigation on biological materials.

If the number of variables (different measurements) is very large, being of the order of magnitude of several hundred, the problem of handling and computing the matrices involved in a factor study becomes extremely laborious. A first approximation of the underlying order can be gained by using a system of cards, one for each specimen, with the edges marked for each measurement. Use of several colors to denote whether the specimen lies above or below the mean for each measurement in turn, enables the worker to get a rough grouping on the basis of the crude correlations involved. Representatives of each of the resulting "clusters" then can be studied by factor methods. The edge-marking technique can also be used in many other time-saving ways. For a complete description of this technique the reader is referred to Thurstone (1948).

The question usually arises in analyses of growth patterns, as to which pairs of

measures, taken on two or more samples, should be analyzed. For example, if 15 measures are made on each member of two groups and it is found desirable to study regression lines of their combinations, the investigator has to deal with C_2^{15} or 105 different possible combinations. The following approach may be used:

1. Selection of those pairs of variables in which data pooled from all samples appears poorly correlated. This can be quickly and economically done by use of the edge card method of crude correlation.

2. Plotting those pairs of variables that appear poorly correlated, as series of scatter diagrams, entering specimens from each sample in a different color or by a different symbol. Inspection of these diagrams is then made to determine in which pairs of variables there is evidence of separation. Those that show such evidence are then analyzed by the method outlined in step 3.

Analysis and comparison of regression lines

The following outline of tests, for the sake of simplicity in presentation, is carried only as far as necessary for the comparison of two samples. It may be extended readily to any number of samples and the equations are written to accommodate such extensions.

A. *Form of lines*

Test hypothesis that each line does not depart from linearity (regression equation of form $y=a+bx$).

Three cases are possible (with two samples):

(1) Both lines linear.

(2) Both lines curvilinear.

(3) One line linear, one curvilinear.

The analysis of variance is applicable to a test for linearity. In this case it is a test for significance of difference between two estimates of residual variance. The best estimate of the true variance of a population, based on the samples analyzed, is obtained from an analysis of variance within the samples, summed and divided by the proper number of degrees of freedom. If there is a significant departure from linearity, the same data fitted to a straight regression line will have a significantly greater residual variance than the best estimate. Thus use is made of the F test for decision as to whether the line in question departs significantly from linearity. The formulae used in this test are to be found in Tippett (1945). A more detailed discussion of the applications of analysis of variance to regression lines is given below.

B. *Comparisons of lines*

B1. *Both lines linear*

B1a. *Test hypothesis that samples have same regression lines* (the general theory is explained in *b*). The first step in the procedure consists of obtaining an estimate of the total residual variance[1] resulting from fitting a separate regression line to each of the samples as follows:[2]

$$(1)\quad \left\{ \left[\sum_1^n (y-\bar{y}_I)^2 - \frac{\left[\sum_1^n (x-\bar{x}_I)(y-\bar{y}_I) \right]^2}{\sum_1^n (x-\bar{x}_I)^2} \right] + \left[\sum_1^n (y-\bar{y}_{II})^2 - \frac{\left[\sum_1^n (x-\bar{x}_{II})(y-\bar{y}_{II}) \right]^2}{\sum_1^n (x+\bar{x}_{II})^2} \right] + \cdots \right\}$$

[1] As pointed out by Tippett (1945), this method of testing hypotheses by analysis of variance is based on the assumption that the residual variance of the deviations of y from the regression line is the same, within allowable standard error, for each of the samples. Biologically speaking, when it is assumed that the residual variance of y is constant, it is, in effect, assumed that the regression equation shows the relationship of the dependent measure to the independent measure about equally well for each of the samples. In closely related groups this is precisely what might be expected, i.e., the pattern (the form of the regression line) is the same but the constants a and b may vary. It is this that we propose to test.

The first step in establishing homogeneity of variance is to test for significance of difference between the standard errors of the several samples. If the tests of the standard errors shows significant difference, the method outlined cannot be used since an additional variable, not entered in the equations, must be accounted for. In addition there arises the problem of biological explanation of the heterogeneity of variance of the samples.

[2] Symbols in the equations have the following meanings: y_I, x_I are variables in sample I; y_{II}, x_{II} are variables in samples II, etc. N_I, N_{II} are the number of individuals in sample I, II, etc. y_t, x_t are the variables in the combined samples.

divided by degrees of freedom $= N_I + N_{II} + \cdots - (2 \text{ no. of samples})$.

The second step is to obtain an independent estimate of the residual variance associated with fitting a single regression line to the combined points of both samples.

$$(2) \qquad \left[\sum_1^n (y-\bar{y}_t)^2 - \frac{\left[\sum_1^n (x-\bar{x}_t)(y-\bar{y}_t) \right]^2}{\sum (x-\bar{x}_t)^2} \right] - [\text{eqn.}(1)]$$

divided by degrees of freedom $= 2$ (no. of samples) $- 2$. An F test of the ratio of these independent estimates of the residual variance gives a probability value as a basis for acception or rejection of the hypothesis.

B1b. *Test hypothesis that samples have the same regression coefficient* (test for the difference of slope between separate regression lines). Here a comparison is made between the residual variance resulting from fitting a series of parallel lines (thus holding *a* constant) through the means of the several samples and the residual variance resulting from fitting separate regression lines to each of the samples. Since the sums of squares of deviations from the separate regression lines are less than, or equal to, the sums of the squares of deviations from the series of parallel lines (equivalent to fitting a single regression line to all the points) the best estimate of the population variance will be based on the fitting of separate regression lines to each of the samples. Therefore, by use of the F ratio, the residual variance based on the single regression line is compared with the best estimate, based on the fit of separate regression lines. If the ratio is approximately 1, it may be concluded that there is no significant difference between these independent estimates and that the lines do not differ in slope. If the ratio value is appreciably greater than 1 probabilities should be obtained from a table of F.

For an independent estimate of the residual variance resulting from fitting one line to all points the following is used:

$$(3) \qquad \left\{ \frac{\left[\sum_1^n (x-\bar{x}_I)(y-\bar{y}_I) \right]^2}{\sum_1^n (x-\bar{x}_I)^2} + \frac{\left[\sum_1^n (x-\bar{x}_{II})(y-\bar{y}_{II}) \right]^2}{\sum_1^n (x-\bar{x}_{II})^2} + \cdots \right\}$$

$$- \frac{\left[\sum_1^n (x-\bar{x}_I)(y-\bar{y}_I) + \sum_1^n (x-\bar{x}_{II})(y-\bar{y}_{II}) + \cdots \right]^2}{\sum_1^n (x-\bar{x}_I)^2 + \sum_1^n (x-\bar{x}_{II})^2 + \cdots}$$

divided by degrees of freedom $=$ (no. of samples $- 1$).

For an estimate of the residual variance due to fitting a separate regression line to each of the samples, the sums of squares of the deviations of y from each regression line is calculated by means of equation (1). In setting up the F ratio the best estimate is put in the denominator; thus in this case:

$$F = \frac{\text{eqn. (3)}}{\text{eqn. (1)}}$$

If the resulting value is less than 1 or is close to 1, no reference to the F table of probabilities need be made.

B2. *Both lines curvilinear.*

Here only the form $y = bk^x$ is considered and thus the equations in B1 are used with the data transformed into logarithms to give the linear equivalent $\log y = \log b - k \log x$.

B2a. *Test hypothesis that two samples have the same regression equation.*

B2b. *If not supported, test hypothesis that samples have same exponent k.* (If not supported then difference must lie in *b*.)

B3. *One line linear and one curvilinear.* No additional tests necessary unless an extension seems desirable.[3]

Interpretation

Interpretation is the final and vital step in any biometric analysis. Except as it entails a knowledge of the meanings of the statistical procedures used, interpretation is a biological problem and failure to recognize this may result in a totally unwarranted, blind faith in the results of statistical analyses. A first problem of interpretation in any biometric study involves selection of levels of confidence, whether, for example, rejection of an hypothesis is to be based on a probability of 0.1, 0.01, 0.001 or any other figure. No rule can be set for this determination and clearly a departure from the objective toward the subjective is involved. The selection of a level of confidence lies in the province of the individual investigator and must be arrived at through logical evaluation of the variables pertinent to the problem and materials with which he is concerned. This step, as others in interpretation, is thus basically a biological matter.

The fundamental concept of biometry, as applied to morphology, is that form can be expressed by measurements. Evolution, viewed in the sense of morphological change of organisms through time, may be expressed in terms of loss, gain or modification of those parts measured. Modification of these parts can be expressed as simple increase or decrease or as a relation to other parts. It is the last category with which studies of relative growth are concerned. Modifications of relationships of hard parts may take the form of a change in relationship of two or more dimensions in which the increments added to one or more with respect to others remain unchanged, or may take a form in which the added increments are modified either in an arithmetic or geometric way. Such changes may appear at the onset of formation of the tissues involved or may appear at any later stage in ontogeny. Presumably any selective value that such changes may have will be operative from the time of their initial morphological expression. It is, therefore, important not only to recognize the change, its nature, amount, and direction, but also to know when it appeared in ontogeny. The techniques outlined in this section are designed for the determination of the existence of such changes and for estimation of the stage at which they appear, their expression at this stage, and their progress during ontogeny.

Once such analyses have been made and satisfactory levels of confidence have been established, the more complex problem of the biological meaning of acceptance or rejection of the various hypotheses concerning regression lines must be solved if the data are to serve their ultimate function. Rejection of an hypothesis that the pattern of relative change of a pair of measurements is the same for two or more samples, and determination of the basis for rejection with respect to position and slope of lines, constitutes an acceptance of a difference in the particular pattern of relative growth. Evaluation of the meaning of the difference from a biological standpoint is quite a different matter, which calls for an analysis of the difference in terms of all information that can be assembled concerning the organisms in question. Part of this may be supplied from a study of all other patterns of relative growth that have been analyzed for the samples and, of course, the more complete the analyses the more comprehensive will be comparisons based upon them. However, an important part of the related information must come from knowledge of other sorts, i.e., ecology, population size, genetics, etc., and information that may be derived from experimental studies.

The zoologist, working with samples of living organisms, has a distinct advantage in such evaluations since he has at his com-

[3] Extension. In cases under A(1) an extension may be desirable in instances in which the means of x of the two samples differ greatly, since there is then the possibility that the two lines may represent segments of a single curved line. If inspection of the scatter diagram gives evidence of such a possibility the following procedure is used. (This may be desirable in some cases under B3 as well.)

Test hypothesis that the samples have the same regression lines of the form $y = bx^k$.

1. If supported where B1a was supported the lines fit a single regression line but data are not definitive of the form of the regression line.

2. If supported where B1a was not supported the two lines probably have a double logarithmic relationship.

mand information on fields of study unavailable to the paleontologist. Paleontologists, however, may use the factor of time, denied to the zoologist, and can determine by careful study much more concerning his samples than is usually done. It is the task of the investigator, either zoologist or paleontologist, to examine critically all relevant data and to use statistical evidence as an indication of a focal point for inquiry rather than as a completely satisfying answer to all his questions. Used in this way, statistical analyses serve to open the door to areas of study that may not be recognized with less critical evaluation of the data.

The opening remarks of this section suggested two general types of problems particularly subject to study by analyses of relative growth, one concerned with differentiation of lower taxonomic categories and the other with comparisons of higher categories. Interpretation of results may be very different as they pertain to these two types of study. In the first instance, it is differences that are being sought, for they are indications of possible separation and of the nature of changes that may be involved in differentiation. In the second, however, differences between the components of a major group are presumably apparent and the common factors become important as an indication of the nature of the unity of the group and as evidence of similarities and differences of two or more major groups. Analyses of the changes of such common patterns with time, either in the major group as a whole or in particular parts of the group, may give evidence of considerable importance regarding the broad patterns of change leading to other major categories.

The problems of interpretation of statistical results derived from studies of growth patterns are not different in kind from those based on information obtained through any other channels. The advantages of relative growth studies in solving certain problems stem from the fact that they are broad in scope and tend to reveal relationships frequently obscured by approaches that are limited to one or a very few stages of development of the organisms being studied.

SIMULTANEOUS ANALYSES OF ALL MEASUREMENTS

The methods outlined in the foregoing section have proved valuable in the solution of actual problems in paleontological research. That they do not represent the most efficient or most informative approach to many problems must be recognized, for in dealing with growth by the use of regression equations information is lost by treating the variables two at a time. Therefore, a logical step in the study of growth as a group character, is the consideration of the simultaneous contributions of all measurements to the form of the organism.

Multiple correlation, in one sense, predicts the values of a dependent variable or measure from given values of n independent variables. There is obtained, thus, an equation that includes n independent variables as a means of estimation of the dependent variables. The more nearly the number of independent variables that have an effect on the dependent variable is approached, the more accurate will be the equation.

By the use of partial correlation it is possible to progress a step farther in analysis of a large number of variables and to arrive at a measure of relationship between a dependent and independent variable by theoretically removing the influence of all other independent variables involved in the total relationship. In considering the totality of measurements, whether ten or several hundred, the biologist is inevitably faced with the difficulty of interpretation of results. One of the first difficulties to be considered is the decision as to which of the measures taken shall be considered independent and which dependent and just what is meant when assumptions concerning dependency are made.

A third approach, essentially non-statistical, involves use of the tools of matrix algebra and geometry in a search for an underlying order in a large number of variables. Here no assumption need be made concerning the dependency of variables. Thurstone's (1947) "Multiple factor analysis" and Wright's (1934) "Path coefficients" deal with this problem. Work from this standpoint is now in progress by the writers.

Burma (1949), applying a method of Hotelling (1931), has considered a number of measurements taken on a series of blastoids to determine, by use of the contributions of all measures taken at once, whether the groups involved are alike or different. He properly stressed the point that information is lost when the number of characters involved is not considered simultaneously. Utilizing analysis of variance, he arrived at a value of F that expresses the significance of differences between the groups in question. The technique, as applied by Burma, however, yields only the information that the groups involved are different in some unexplained way. It is doubtful that the results are commensurate with the work involved. Questions that are of great interest to a taxonomist remain unanswered, namely:

1. Which of these variables are important in differentiating the results?

2. In what way do these variables differ?

A simple comparison of variables taken two at a time can only give a partial answer to these questions. Barnard (1935), incorporating both multiple and partial correlation in a series of logical and well integrated steps, has made an excellent attempt to answer these questions in a study of four series of Egyptian skulls. The writers believe that such procedures, formulated by Barnard and by Fisher, extended and in some respects modified, will provide a powerful tool for treatment of several types of paleontological problems and it is hoped that this short discussion of possible methods of attack will stimulate research along such lines on paleontological materials.

REFERENCES

BARNARD, M. M., 1935, The secular variations of skull characters in four series of Egyptian skulls: Ann. Eugenics, vol. 6, pp. 352–371.

BURMA, B. H., 1949, Studies in quantitative paleontology, II, Multivariate analysis: Jour. Paleontology, vol. 23, pp. 95–103.

CENDANA, S. M., and FERMIN, D. V., 1940, Biology of *Kaloula picta* (Dumeril and Bibron), with special reference to its development and breeding habits: Philippine Agriculturist, vol. 28, pp. 626–655.

FELLER, W., 1940, On the logistic law of growth and its empirical verification: Acta Biotheoretica, vol. 5, no. 2, pp. 51–66.

FISHER, R. A., 1946, Statistical methods for research workers. Biol. Mon. Manuals, V, 1 vol., 10th ed., Edinburgh and London, Oliver and Boyd.

GRAY, S. W., 1946, Relative growth in a phylogenetic series: Am. Jour. Sci. vol. 244, pp. 297–807.

HERSH, A. H., 1934, Evolutionary relative growth in titanotheres: Am. Naturalist, vol. 68, pp. 537–561.

HOTELLING, H., 1931, The generalization of Student's ratio: Ann. Math. Statistics, vol. 5, pp. 161–215.

HUXLEY, J. S., 1932, Problems of relative growth. London, Methuen and Co., Ltd.

KLAUBER, M. K., 1937, A statistical study of rattlesnakes: San Diego Soc. Nat. History Occ. Paper 3.

LUMER, H., and others, 1942, On the significance of the constant b in the law of allometry y equals b times x to the sigma: Am. Naturalist, vol. 76, pp. 364–375.

POPE, C. H., and POPE, S. H., 1949, Notes on the growth and reproduction of the slimy salamander, *Plethodon glutinosus:* Fieldiana, Zoology, Chicago Nat. Hist. Mus., vol. 31, pp. 251–261.

REEVE, E. C. R., 1940, Relative growth in the snout of the anteaters: Royal Zool. Soc. London Proc., ser. A, vol. 110, pp. 47–80.

——, 1941, A statistical analysis of taxonomic differences within the genus *Tamandua:* Royal Zool. Soc. London Proc., ser. A, vol. 111, pp. 279–302.

——, and HUXLEY, J. S., 1945, Some problems in the study of allometric growth, In: Essays on growth and form, pp. 121–156. Oxford Univ. Press.

RICHARDS, O. W., 1936, Analysis of the constant differential growth ratio: Carnegie Inst. Washington Pub. 29, pp. 171–183.

——, and KAVANAUGH, A. J., 1945, The analysis of growing form, In: Essays on growth and form, pp. 188–230. Oxford Univ. Press.

ROBB, R. C., 1935, A study of mutations in evolution, I, Evolution in the equine skull, II, Ontogeny in the equine skull: Jour. Genetics, vol. 31, pp. 39–52.

SIMPSON, G. G., and Roe, A., 1939, Quantitative zoology. New York and London, McGraw-Hill Book Co.

SNEDECOR, G. W., 1946, Statistical methods, 3rd ed. Ames, Iowa, Iowa State College Press.

TIPPETT, L. H. C., 1945, The methods of statistics, 3rd ed. London, Williams and Norgate.

THURSTONE, L. L., 1947, Multiple factor analysis. Univ. of Chicago Press.

——, 1948, Edge-marking method of analyzing data: Jour. Amer. Statistical Assoc., pp. 451–454.

WRIGHT, S., 1934, The method of path coefficients: Ann. Math. Statistics, vol. 5, pp. 161–215.

JOURNAL OF PALEONTOLOGY, VOL. 25, NO. 2, PP. 224–226, 2 TEXT FIGURES, MARCH 1951

A NEW METHOD OF SAMPLE PREPARATION

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ABSTRACT—This paper describes a new and highly successful method of breaking down rock samples so that they can be prepared for the study of their discrete parts, either organic or inorganic. It also presents all information essential to the assembling of the necessary equipment. This method should be of particular interest to petroleum geologists who handle large numbers of small samples.

MANY methods for separating fossils from the rock matrix have been described in the literature. These include, in addition to the conventional method of boiling and decanting, various chemical expanders, repeated drying and soaking, freezing and thawing, pressure cooking, acidation, boiling in deflocculating chemicals, and crushing before washing. Some references to them are listed in the bibliography. Each of the described methods is limited in application. Some destroy all but the more durable fossils and so are of limited usefulness. Crushing, for example, breaks most of the fossils and makes it necessary to work with partial specimens. Many samples known to contain abundant fossils must be discarded because they cannot be successfully treated. In addition to the limited application and unsatisfactory results of the known "washing" processes, these all require considerable personal attention and are time-consuming.

A new method, for which the name "Campbell method" is proposed, is now available. This process was developed by Campbell after he had spent many months in trying all the old processes. Later, when the new method showed promise of superior results, he devoted many more months to its refinement.

Campbell, although lacking in academic training in geology, has developed an avid interest in, and a thorough knowledge of, the geology of his section of Iowa. In pursuit of his hobby of fossil collecting, he early became aware of the microscopic organisms, primarily conodonts, present in the local Pennsylvanian rocks. It was his attempts to remove these specimens that led to his experiments. He first tried dental plaster in an effort to pull the specimens free from the enclosing shale. He then tried many types of acids, mostly to no avail and at best with only fair results.

During the search for some satisfactory way of handling the samples, the description of a method of washing by tumbling the material in a closed container was read. This proved to be highly unsatisfactory, both in time consumed and in results obtained. At first the sample balled up in one end of the tumbler and so stopped effective washing. Repeated boiling and decanting was tried, after which the sample was again subjected to tumbling, but most of the tiny, fragile specimens were badly broken.

The tumbling method was discarded in favor of an experiment which involved the placing of a small sample, along with a reasonable amount of water, in a small oval-shaped plastic tube (toothbrush container) which was then slowly shaken manually to produce a sliding, washing action. The results were not too unsatisfactory but the process was entirely too time-consuming to be practical. Therefore, a small section of ¾-inch metal conduit was cut and threaded so that it could be capped. After placing the sample and water in it, the tube was mechanically rotated end over end at a speed of 30 r.p.m. (60 tumbles). This produced fairly good results but apparently the rotation was too slow.

Next were tried 30-inch sections of 3-inch glass tubing rotated at speeds ranging from about 28 r.p.m. to 38 r.p.m. For some undetermined reason, the tubes broke each time the experiment was tried. Apparently implosion was caused by partial vacuum developing as a result of air being driven from the tube during tumbling. At this

stage of experimentation it had been determined that tubes with length ten times the diameter worked most successfully. In order to increase production, an apparatus with several tubes arranged around the axis of rotation like spokes of a wheel was tried but abandoned in favor of another in which the tubes were rotated as closely as possible around the midpoints of their long dimensions. Further experiments revealed the impractical features of large-sized tubes (4×4-inch boiler tubing was used); the specimens were badly broken.

The most successful set-up to date has used metal conduit tubes measuring $1\frac{1}{2}\times 18$ inches, threaded on both ends and sealed with caps against heavy rubber washers, with a $\frac{3}{8}$-inch blow-out safety valve in one (occasionally a sample inexplicably will explode), rotated at a speed of 36 r.p.m. It has been mathematically determined that 36.9 r.p.m. will result in maximum efficiency with tubes of this size. A number of samples can be washed at once by arranging several pairs of tubes at right angles to each other (fig. 1), or by mounting them alternately (fig. 2). The safety valve is made by drilling a $\frac{3}{8}$-inch hole in the cap and placing a $1\frac{1}{2}$-inch rubber gasket inside it. Such an apparatus can be expanded by the addition of more tubes, clutches, etc., to handle a very large number of samples at one time and yet give control over any desired unit of the entire group.

It has been determined that in washing argillaceous samples tubes should be filled to about one-fourth capacity with the sample and then to about three-quarters capacity with water. The amount of water necessary varies with the hardness of shale. If it is soft, or the fossils are delicate, more water should be used than with indurated material. The sample should be washed for from 8 to 24 hours (experience will dictate the length of time necessary) until the residue is free of clay. Deflocculents may decrease the washing time. Then the sample is poured from the tube into a deep container (a glass gallon jar is very satisfactory), agitated to bring the clay into suspension, and allowed to set for a few minutes (1 to 5, depending on size of organisms sought) to allow specimens to settle. The clay-bearing water is poured off, and this procedure is repeated until the water remains clear during agitation. This may require as many as 18 rinsings. The sample is then placed in a container and slowly dried. If the sample does not disintegrate to the desired degree during the first period of mechanical washing, it should be thoroughly dried before the washing is repeated. Separating the clay from a washed sample can be speeded up considerably if the sample is poured into a fine-meshed screen and washed under a stream of water. The mesh size of the screen will be determined by the size of the organisms sought—a 200-mesh screen will retain all forms that are normally studied. Harder rocks should be broken into $\frac{1}{2}$-inch or smaller pieces before being placed in the tube.

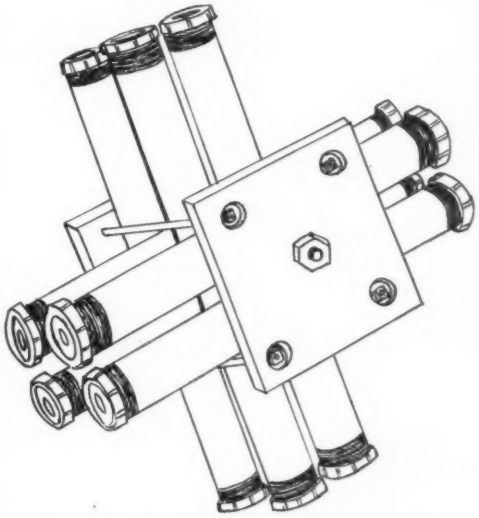

FIG. 1—Tubes arranged around center of rotation; after Campbell's model.

The Campbell method has produced over 1600 specimens from a unit of sample equivalent to another which yielded only six when processed by the conventional boiling and washing method.

To date, the Campbell method has been used successfully to wash Ohio Pennsylvanian shales; Upper and Lower Ordovician dolomite; samples of Silurian, Devonian, Mississippian and all types of Pennsylvanian

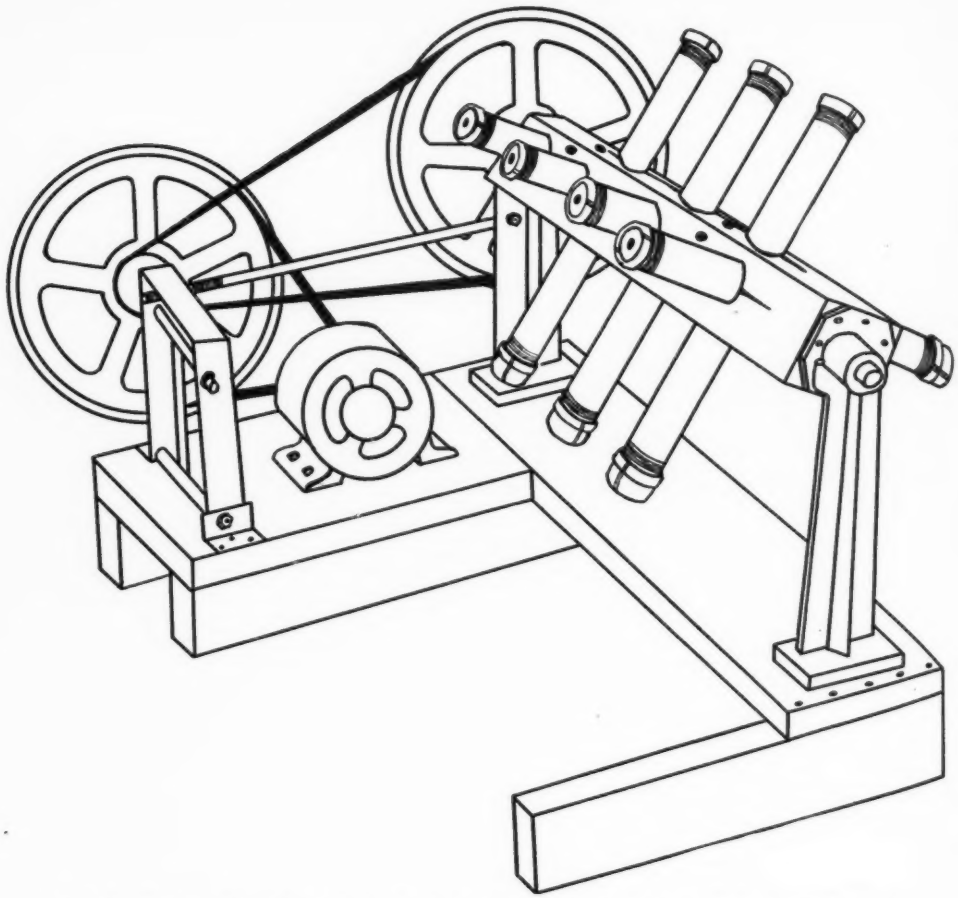

FIG. 2—Center of rotation passes through tubes; after Iowa State College modification.

rocks from Iowa; more than 200 samples of Austin chalk from Texas; and Marianna chalk from Alabama. The success of this method is attested to by the fact that samples processed by it have furnished the specimens for several important studies of Iowa conodonts.

The assembly shown in figure 1 is being used on a machine built by Campbell. The machine shown in figure 2, patterned after Campbell's model, was recently built at Iowa State College. It is still being tested with variations in method. To date it has proved highly satisfactory. It has also been used as a ball-mill and produced excellent results in pulverizing feldspar.

REFERENCES

BRANSON, E. B., and MEHL, M. G., 1933, Conodont studies no. 1: Univ. Missouri Studies, Quart. Res., pp. 11–12.

CAMP, C. L., and HANNA, G. D., 1937, Methods in paleontology. Berkeley, Univ. California Press, pp. 99–100.

CUSHMAN, J. A., 1948, Foraminifera, their classification and economic use, 4th ed. Cambridge, Harvard University Press, p. 26.

DRIVER, H. L., 1927, An aid in disintegrating samples for micro-organic study: Jour. Paleontology, vol. 1, pp. 253–254.

GLAESSNER, MARTIN F., 1948, Principles of micropaleontology. New York, John Wiley & Sons, p. 37.

HANNA, G. D., and CHURCH, C. C., 1928, Freezing and thawing to disintegrate shales: Jour. Paleontology, vol. 2, p. 131.

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PALEONTOLOGICAL NOTES

THE CUSHMAN COLLECTION OF FORAMINIFERA[1]

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U. S. National Museum

On May 22, 1950, the Cushman Collection of Foraminifera was moved to Washington, D. C., and installed in Room 304 of the U. S. National Museum. In accord with the provisions in the will of Dr. Joseph A. Cushman, the National Museum collection and the Cushman collection are merged in order to facilitate administration and use of the material. The writer serves as curator of these collections of Foraminifera.

[1] Published by permission of the Secretary of the Smithsonian Institution.

The Cushman collection includes approximately 150,000 mounted slides, at least 25,000 slides of type and figured specimens, a library of over 4,000 books and reprints on Foraminifera, and a card catalog of over 98,000 species cards.

The Cushman collection, unrivaled in the world, combined with the fine material already in the National Museum, makes a superb study collection. Facilities are available in the National Museum to help serious American and foreign students in their studies of Foraminifera.

A NEW GONIATITE LOCALITY IN THE WHITE PINE SHALE OF NEVADA

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During the 1949 summer field season, Fred L. Humphrey of Stanford University discovered an abundance of goniatites at a new locality in the White Pine shale of east-central Nevada. He sent about 35 specimens to us for study. They are only moderately well preserved, but most of them are clearly referable to *Cravenoceras hesperium* Miller & Furnish—they show the characteristic shape of conch, transverse test ornamentation, sinuous transverse constrictions, and sutures. In the matrix which adheres to one individual there is a small specimen that does not retain its sutures but almost certainly represents the genus *Epicanites*.

These cephalopods are part of a fauna which is now known to be of widespread occurrence in North America, Europe and northern Africa. It was originally described by European authors and then was recorded by Girty from the Caney shale of Oklahoma. Fairly recently, in this Journal, we have added to and summarized the existing knowledge of the fauna in two papers based on large collections from the Barnett shale of Texas and the White Pine shale of Nevada.

The purpose of the present note is to call attention to the discovery of this well known Mississippian ammonoid zone at a locality in which it had not been found heretofore. The specimens under consideration came from the upper portion of the White Pine formation (where it is in fault contact with Pennsylvanian limestone) in the north-central part of sec. 10, T. 17 N., R. 58 E., M.D.M., near U. S. Highway 50, about halfway between Eureka and Ely, Nevada; that is, approximately 1½ miles S. 25° W. of the permanent State Highway Maintenance Station on the east side of Little Antelope Summit and 2 miles N. 70° W. of the junction of Highway 50 and the Hamilton Road, in White Pine County. The collection is to be deposited in the United States National Museum.

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NOMENCLATURAL NOTES

THE GENERIC NAME *BILOBITES*

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Dr. Preston E. Cloud, Jr., recently published reasons for using the name *Dicaelosia* for the brachiopod commonly called *Bilobites* (Cloud, 1948, pp. 373–374). Dr. Caroline Heminway Kierstead brought the change to the attention of the Joint Committee on Zoölogical Nomenclature, and asked for an opinion on the possibility of retaining the more familiar name.

The majority of the Committee thinks that the rules of nomenclature should be strictly applied in this case, and that *Bilobites* should not be used for an orthoid brachiopod.

While I was preparing a brief of the case for the consideration of the Committee, some new facts turned up which Cloud had not mentioned, and which seemed to alter the situation. In particular, it seemed that the first valid use of the name was not by Dekay, but by d'Orbigny. A note based on this opinion was submitted for publication. Subsequently Professor Weller discovered that the name had been used by Rafinesque, and the summary of his usage below is by Weller. However, Professor Weller does not agree with the opinion of the Committee as a whole, holding, with a minority, that this is a case in which the International Commission should be asked to suspend the rules to allow retention of *Bilobites* for the brachiopod.

If any paleontologist feels sufficiently strongly that this should be done, the Committee will be glad to assist in drawing up a petition, and in presenting it, although the vote of the Committee was that such a petition would not command their support.

The rather tangled history of the name is discussed below, under the four categories for which it has been used. Quotations are given rather fully, since some of this early literature is not generally accessible.

1. *Bilobites*, THE TRILOBITE[1]

This name was first used for a trilobite by Rafinesque (1831, p. 2) who wrote: "Bilobites, Raf. disc. 1819. Head bilobed oculated; 2 ap. *B. lunulata*, lunulate head: 2. *B. lobata*, head with two obtuse lobes. Both from the Knobhills of Kentucky." The following year (1832, p. 72) he abandoned this name, stating: "I have changed the name [to *Promenites*] as there are several G. [=genera] bilobites," and listed the species *P. lunulata* and *P. bilobata* without description.

The next notice of the trilobite *Bilobites* is in Goldfuss (1843, p. 566) where Rafinesque's two original species are listed.

Although Rafinesque's description is wholly inadequate by modern standards, it is obviously unfair to judge a description published in 1831 by present requirements. As a matter of fact, many ancient genera, no better characterized originally than this one, are recognized as valid today because subsequent workers have identified them with specimens. It happens that no specimens have been identified subsequently with Rafinesque's genus but this has no necessary bearing on the nomenclatural validity of the name he introduced.

2. *Bilobites*, THE PROBLEMATICUM

Sometime before April, 1834, Alcide d'Orbigny presented to the French Academy of Sciences an account of his travels in South America. This was given to a number of readers, who presented their reports to the meeting of the Academy on April 21, 1834. J. P. E. Cordier reported on the geological portion, and his report was printed (Cordier, 1834, 1842?, 1922) with those of the other critics. It would seem that at this

[1] By J. Marvin Weller.

time there was no real manuscript, since Cordier remarked:

Il serait bien regrettable que de tant de matériaux précieux, acquis au prix de tant d'efforts, de fatigue, de constance, et de sacrifices, il ne restât que la collection de roches qui est déposée au Muséum. Il est évidemment à désirer que M. d'Orbigny puisse rédiger ses observations et en faire jouir le mond savant, en les publiant accompagnées d'une carte géologique qui en résume les résultats les plus important.

In the course of his report Cordier (1834, pp. 113–114; 1842?, p. 9; 1922, p. 508) added:

On trouve . . . et un genre de fossiles particulier déja observé en Europe, et non encore défini, qu'on pourroit provisoirement nommer bilobite, et qui paroit avoir appartenu à des animaux perdus, intermédiaires entre les cirrhopodes et les crustacés.

In 1839 d'Orbigny published the illustrations for the paleontological part of his "Voyages," and figured two species of *Bilobites* on plate 1 (d'Orbigny 1839). This plate is headed "Géologie . . . Pl. I," and has at the foot: "Terrains de transition de Bolivia" and the names of the illustrated forms, including: "1, Bilobites rugosus, d'Orb., 2-3, B. . . . furcifer, d'Orb." I do not think the date of these plates has been noticed, and indeed Sherborn & Woodward (1901, p. 389) thought the dating of the plates of the "Voyages" hopeless. My citation of the date is based on an entry in the Bulletin of the Société géologique de France, vol. 10, p. 141, where, in an account of the meeting of March 18, 1839, it is stated:

M. Alcide d'Orbigny offre a la Société les planches de fossiles qui font partie de son ouvrage sur l'Amérique méridionale. Les espèces figurées sont les suivantes: Bilobites rugosus, d'Orb., . . . furcifer, id. . . .

On page 163 of the same volume, in the list of gifts to the Society, is the entry: "Orbigny (Alcide d'). Sept planches lithographiées de fossiles de l'Amérique du Sud."

By 1842, when the text of his work appeared, d'Orbigny had learned of De Kay's "*Bilobites*," and we have the following note (d'Orbigny, 1842a, p. 158, footnote):

Ces fossiles, que, dans son rapport de 1834, M. Cordier designé commes des *Bilobites*, ont été publiés, plus tard, sous ce nom (Paléontologie, pl. I, fig. 1, 3). M. Dekay ayant employé cette dénomination pour d'autres corps, je me vois forcé de la changer, et je nomme ce genre *Cruziana*. On le trouve en France dans la partie la plus inferieure des terrains siluriens de la Bretagne.

In the section on paleontology we find under the heading *Cruziana:*

Ces restes organisés ont été appelés *Bilobites*, par M. Cordier, dans son Rapport a l'Institute sur mes travaux. Je les avais, d'apres ce savant, figurés sous cette dénomination dans mes planches; mais j'ai reconnu dupuis que M. Dekay avait déjà donné le même nom a un fossile tout différent, et j'y substitue celui de *Cruziana*, en dédiant le genre au général Santa-Cruz (d'Orbigny 1842b, p. 30).

Bilobites has been used for these fossils only rarely in a generic sense (e.g., by Fritsch, 1908, p. 12, seq., where three new species are described from the Ordovician of Bohemia), but more usually *Cruziana* is used as the genus, with "Bilobites" kept as a vernacular name (e.g., Lebesconte 1886, p. 803, seq.) This usage has been summarized by Thoral (1946, p. 44):

Quant au nom de genre à employer, celui de *Cruziana* d'Orb. me paraît indiscutable. En effet, le term de Bilobites qui leur a été attribue par Dekay avait auparavant été employé par Linné pour désigner des Brachiopodes de la famille des *Orthidae*. Ce vocable est toutefois resté dans le langage courant, parce que commode et expressif, pour désigner toutes les traces bilobées quel que soit le genre scientifiue dans lequel on les range. C'est l'opinion adoptée ici.

3. *Bilobites*, THE CLAM

In 1824 Dekay (p. 45, seq., pl. 5) described and figured some fossils, and this work has been taken by Cloud and others to mark the first use of *Bilobites* as a generic name. Since this paper is available to few workers, it may be well to quote passages at enough length to make its content clear. Dekay wrote (p. 45):

Among the numerous fossils in the cabinet of the Lyceum, several are labelled under the name of Bilobite. They were collected . . . &c. The name of Bilobite is not to be found in any modern work on Oryctology; and it is probable that its application in this instance has been suggested by its peculiar appearance.

Dekay then described the specimens, and speculated on their probable nature and the question whether they were compressed. He concluded (p. 48):

That this compression is not accidental, is, it is

supposed, evident from the fact, that all the Bilobites have the appearance of being compressed in a similar direction, a character which is too constant to have been occasioned by accidental causes. From these observations, it is evidently a futile attempt, in the present state of our knowledge respecting these fossils, to distinguish them into separate species. The term Bilobite may be retained as a distinctive appellation, comprehending casts of several extinct species of cardium, from the above mentioned localities.

Throughout, a single specimen is referred to as a Bilobite, and the word Bilobites is used only as a plural. The title of the article is "Note on the Organic Remains, termed Bilobites . . . ," but the running head is "On the Bilobite." There is no description of the plate, but the word "Bilobites" is engraved on the plate itself.

What have we then, from the point of view of nomenclature? An author need not *intend* to erect a genus, but may quite validly do so inadvertently, as Quenstedt did in the case of the brachiopod *Bilobites*. So that the evident fact that Dekay did not mean *Bilobites* as a generic name does not come into consideration. The question is: did he in fact use it as a generic name, or in such a way that another worker could take it to have been used as a generic name? I think not.

If the plate stood alone, then we would have to consider the word Bilobites in its title to be a word in classical form, in the nominative singular, and therefore a perfectly valid name for the objects figured. But taken in conjunction with the text, it is obvious that we would be wrong, and that Bilobites, in spite of its classical form, is an English word in the plural, and therefore unavailable as a generic name. I think that we must consider the total situation, and my own opinion is that no genus has been erected here.

This interpretation seems to have been the one accepted by Dekay's contemporaries, for we find that Conrad (1840, p. 207) in a description of *Pleurorhynchus* [*Conocardium*] *cuneus* stated: "This is the fossil well known as the bilobite, which is a crushed specimen."

Bilobites, in this sense, first appeared as a generic name in Bronn (1848, p. 169), where it is listed with one unnamed species, and a reference to Dekay's figures.

4. *Bilobites*, THE BRACHIOPOD

This name is commonly given as dating from Linnaeus, 1775, but Cloud (p. 373) has shown that this is incorrect, and that the name does not appear in Linnaeus.

It was first used by Quenstedt (1869, p. 550), who, in describing *Orthis biloba*, stated: "Erst Davidson wies ihnen hier ihren Platz an, und King erhob sie zur *Dicoelosia* (δίς, doppelt, χοῖλος, hohl) = *Bilobites* Linn. ed. Muller 1775 VI pag. 325." Quenstedt also gave it in the list of genera, page 715.

Cloud has stated that the proper name for this genus is *Dicaelosia*, and that Schuchert and LeVene emended this to *Dicoelosia* in 1929, but this does not seem to be the case.

It is true that King in the actual description of his new genus gave the name as *Dicaelosia*, but I think it obvious that this is a typographical error, occasioned by the great similarity of the diphthongs *ae* and *oe* in italics. Thus in his index (p. 256) King spelled the word "Dicoelosia" (in Roman), and in the original description gave the derivation "From δίς, twice, and κοιλος, a cavity; in allusion to the shell appearing as if departed into two cavities." I think that a "typographical error is evident," and that the name must be *Dicoelosia*.

SUMMARY

We thus have the following genera:

Bilobites Rafinesque 1831, an unidentifiable trilobite.

Bilobites d'Orbigny 1839 [not Rafinesque 1831], a problematic fossil. Objective synonym: *Cruziana* d'Orbigny 1842.

Bilobites Bronn 1848 [not Rafinesque 1831], a pelecypod. Possible senior synonym: *Conocardium* Bronn 1834.

Bilobites Quenstedt 1869 [not Rafinesque 1831], a brachiopod. Senior synonym: *Dicoelosia* King 1850.

REFERENCES

BRONN, H. G., 1848, Index Palaeontologicus oder übersicht des jetzt bekannten Fossilen Organismen I. Abt., I. Hälfte. Stuttgart, F. Schweizerbartische Verlagshandlung.

CLOUD, P. E., JR., 1948, *Dicaelosia* versus *Bilobites:* Jour. Paleontology, vol. 22, pp. 373–374.

CONRAD, T. A., 1840, Third annual report on the Paleontological Department of the Survey:

State of New York Assembly Paper 50, pp. 199–207.

CORDIER, [P. L. E.], 1834, Rapport sur la partie géologique du voyage de M. d'Orbigny dans l'Amérique méridionale: Mus. histoire nat. Nouvelles Annales, tome 3, pp. 107–115.

——, 1842?, idem, paged 4–10. In the University of Michigan Library bound with volume 3 of d'Orbigny, but presumably published separately.

——, 1922, Procès-verbaux des séances . . . jusqu'au mois d'août 1835, tome 10, pp. 505–509: Inst. de France Acad. des Sciences.

DEKAY, J. E., 1824, Note on the organic remains, termed Bilobites, from the Catskill Mountains: Lyceum Nat. History, New York, Annals, vol. 1, pt. 1, pp. 45–49, pl. 5.

FRITSCH, ANTON, 1908, Systême silurien du centre de la Bohême: Problematica Silurica. Prague.

GOLDFUSS, G. A., 1843, Systematische Übersicht der Trilobiten und Beschreibung einiger neuen Arten derselben: Neues Jahrb., Jahrg. 1843, pp. 537–567, pls. 4–6.

KING, WILLIAM, 1850, A monograph of the Permian fossils of England: Palaeontographical Soc., vol. 3.

LEBESCONTE, PAUL, 1886, Constitution générale du Massif breton comparée a celle du Finistère: Soc. géol. France Bull. (3), vol. 14, pp. 776–819, pls. 31–36.

ORBIGNY, ALCIDE D', 1839, Voyages dans l'Amerique meridionale (le Brésil, la république orientale de l'Uruguay, la république argentine, la Patagonie, la république du Chili, la république de Bolivia, la république du Pérou), executé pendant les anées, 1826, 1827, 1828, 1829, 1830, 1831, 1832 et 1833, Paléontologie, 7 pls. Paris, Pitois-Leverault; Strasbourg, Ve. Leverault.

——, 1842a, idem, tome 3, 3e partie.

——, 1842b, idem, tome 3, 4e partie: Paléontologie.

QUENSTEDT, F. A., 1869, Petrefactenkunde Deutschlands, I. Abt., 2 Bd., Brachiopoden, Lief. 4, pp. 465–748.

RAFINESQUE, C. S., 1831, Enumeration and account of some remarkable natural objects in the cabinet of Prof. Rafinesque, in Philadelphia.

——, 1832, On the genera of fossil trilobites or Glomerites of North America: Atlantic Jour., vol. 1, pp. 71–73.

SHERBORN, C. D., and WOODWARD, B. B., 1901, Notes on the dates of publication of the natural history portions of some French voyages, part I: Annals and Mag. Nat. History (7), vol. 7, pp. 388–392.

THORAL, MARCEL, 1946, Cycles géologiques et formation nodulifères de la Montagne Noire: Mus. histoire nat. Lyon Nouvelles Archives, fasc. 1.

ON THE TYPE OF *PSEUDAMUSSIUM* AND OTHER NOTES ON PECTINID NOMENCLATURE

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INTRODUCTION

During the preparation of a monograph on the Pectinidae, the author has encountered, not unexpectedly, several points of nomenclature and validity which are commonly misunderstood. Since these misunderstandings are especially prevalent among American workers not completely familiar with European and Asiatic species, a few are dealt with in this preliminary paper for the assistance of other students of the group.

DISCUSSION

Subgenus PSEUDAMUSSIUM H. & A. Adams, 1858

The genera of Recent Mollusca, vol. 2, p. 553

The determination of a type for this subgenus has been the thorniest problem in Pectinid nomenclature, except for that of *Pecten* itself. Discussions regarding the identity of Klein's species are of purely historical interest, since it does not necessarily have any status in the determination of type. Since so much confusion has arisen, a brief summary of the history of the use of *Pseudamussium* will make for clarity. It is hoped that the points brought out will enable the conclusion to be accepted by all.

The first habilitation of the name after 1758 was apparently that by Otto Mörch of Copenhagen, in the Yoldi Catalogue (1853, p. 59). The validity of this work for nomenclatural purposes is virtually never discussed by those who accept or reject it, and it is a peculiarly difficult point. Like the "Museum Calonnianum" for the Humphrey Collection (1797), Mörch's "Catalogus" was simply a sale catalogue for Don Alphonso's Yoldi collection. The former has been re-

jected by the International Commission (Opinion 51). The "Museum Boltenianum," on the other hand, was accepted as valid (Opinion 96), and the case of the Yoldi Catalogue appears to fall somewhere between the two. It cannot be rejected as surely as was the Humphrey Catalogue, which was anonymous and had scarcely any influence on the nomenclature even of its own period. Mörch was very young at the time of preparing his work, but he later became a recognised authority on nomenclatural questions in conchology, and a prolific publisher in a number of authoritative journals. In this respect, he is much more worthy of consideration than Bolten or Peter Röding.

The real question at issue, therefore, is whether the catalogue was truly "published" in the restricted sense required for nomenclatural purposes. Was it *made available* to scientists in general, as distinct from being printed for the use of a small group of would-be buyers at one place and at one time? The answer to both these questions seems to be "no," and in this respect the Catalogue differs completely from the "Museum Boltenianum," which ran to three editions and has been in universal use for over 100 years.

It must be doubted, therefore, whether Mörch's authorization of *Pseudamussium* has any validity. Should it be upheld, however, we must see what definition it can give to the name. Mörch referred two species to the subgenus—*Pecten glaber* Linné, and *Pecten septemradiatus* Müller. No type was designated. Stewart (1930, p. 122) considered that no designation was necessary, since Mörch placed "*P. pseudamusium* Ch." in the synonymy of *P. septemradiatus*, and the latter therefore becomes the type by absolute tautonymy. Stewart's view was upheld in North America by Mrs. Rowland (1938, pp. 61–62), and in Europe by Johannes Thiele (1934, p. 807). Unfortunately, *P. pseudamussium* and *P. septemradiatus* are not by any means the same species, so that the type by tautonymy is ambiguous. Grant and Gale (1931, p. 236) suggested that we must clearly accept *P. pseudamussium* as representing Mörch's idea of the type by tautonymy, but this is not enough. Mörch's conception of *P. pseudamussium* was based on an erroneous synonymy by Chemnitz—the trivial names alone are almost sufficient to show the differences. Moreover, "*pseudamussium*" as a trivial name cannot date from Chemnitz (1784, p. 298, table 63, figs. 601, 602), who was not a binomial author. It was not given a valid designation until 1842, by G. B. Sowerby (p. 56, pl. 19, figs. 211, 212, pl. 20, fig. 243). The species of Chemnitz which is synonymous with *P. septemradiatus* is *P. danicus* (1795, p. 267, table 207, fig. 2043).

This failure of the type by tautonymy makes it impossible to designate a type to validate Mörch's authorization of *Pseudamussium*. Thus Kobelt (1881, p. 373) designated *P. glaber*, but this conflicts with the Rules (Article 30-d). Even if the Yoldi Catalogue is accepted as valid, therefore, we must seek a type for this particular unit from some later habilitation of the name.

The next usage was by Henry and Arthur Adams (1858, p. 553). They did not designate a type, but listed 21 species in alphabetical order, and under modern views their species are far from cogeneric. However, a number of them remain available for designation as the type of *Pseudamussium*. Mrs. Rowland (1938, p. 61) claimed that Chenu designated *P. dispar* Lamarck as type. This is incorrect, Chenu having merely listed *P. dispar* as an example (1862, p. 184), along with *P. pseudamussium* Lamarck and *P. glaber* Linné. Moreover, Chenu dated the subgenus from Klein, which was untenable in view of the later uses of it by Mörch and by the Adams brothers.

The first unequivocal designation of type came from Stoliczka (1871, p. 426), who named *P. exoticus* Chemnitz. This designation was followed by many later workers, often supported by the quite correct claim that Chemnitz's species is the same as *P. pseudamussium* Sowerby. Among the adherents of this view were Fischer (1886, p. 944), Philippi (1900, p. 108), Cossman (1914, p. 106), von Teppner (1922, p. 208) and Marwick (1928, p. 456). Nonetheless, the designation is invalid, firstly because Stoliczka dated the subgenus from Klein, and secondly because the trivial name *exoticus* cannot date from Chemnitz (1795, p. 262, table 207, figs. 2037, 2038). The first valid habilitation of *P. exoticus* was by Dillwyn (1817, p. 259), who

applied the name to a smooth shell from off the coast of Gambia—the *P. pseud-amusium* of Klein. Verrill (1897, p. 60) and Arnold (1906, p. 50) also adopted Stoliczka's type, but they dated the subgenus from the Adams brothers, in whose list the species under that name did not appear.

The first to date *Pseudamussium* from the Adams brothers was Dall (1886, p. 219), who designated as type *Pecten dispar* Lamarck (1819, p. 173). Dall correctly stated in support of his designation that this species is the same as Lamarck's *P. pseudamussium*. Unfortunately, the latter name does not date from Lamarck, and that author's *P. dispar* is a dead synonym of *P. hybridus* Gmelin (Systema Naturae, Ed. XIII, 1792, p. 3318). In 1898, Dall again accepted the Adams authorization, and designated *P. hybridus* (p. 751). This is the first valid designation. However, a strict application of the rules can be made to defeat this also, on grounds of ambiguity, since, on page 697 of the same work, Dall clearly accepted Stoliczka's designation of *P. exoticus* Chemnitz. Should this objection be upheld, there is a further designation of *P. hybridus* by Suter (1913, p. 880). Suter's designation was accepted by Woodring (1925, p. 72) and by Cox (1948, p. 64), and should be upheld if that of Dall is declared ambiguous.

Genus NEITHEA Drouet, 1825
Soc. linnéenne Paris Mém.,
vol. 3, 1824, p. 186

For more than a hundred years, this name was used for the pronouncedly planoconvex Cretaceous forms with heavy projecting ribs and more or less unequal ears. Stewart (1930, p. 115) claimed that this usage was incorrect, since Chenu's designation of *N. aequicostata* Lamarck made the genotype a small species with quite even ribbing and small equal ears (Chenu, 1862, p. 186, figs. 941–944). Stewart therefore proposed the new subgenus *Neitheops* for the forms with unequal ribs, with *N. grandicosta* Gabb as type.

Prior to Chenu's designation, however, there were at least three designations of *N. quinquecostata* J. Sowerby—by Herrmannsen (1847, p. 110), Gray (1847, p. 200), and Searles Wood (1861, p. 36). Stewart suggested that these designations were invalid on the ground that *N. quinquecostata* was not in Drouet's original list. But neither was *N. aequicostata*, except in synonymy. Drouet's first species was his own *N. pectinoides* (p. 186, pl. 7, figs. 1, 2), and this is quite clearly Lamarck's *Pecten aequicostatus*, as has never been contested (1819, p. 181). But Drouet also included in his list *N. versicostata* (*Pecten versicostatus* Lamarck, 1819, p. 181), and this is equally clearly the same as *N. quinquecostata* (J. Sowerby, 1814, p. 122, pl. 56, figs. 4–8). Thus *N. quinquecostata* has exactly the same right as has *N. aequicostata* to receive the subsequent designation as type, and Herrmannsen's designation should be upheld.

No one should seriously suggest that the two species are not cogeneric. If the acceptance of *N. quinquecostata* as the type of *Neithea* were to involve not merely the synonymy of *Neithea* and *Neitheops*, but also the creation of another subgeneric name for the *N. aequicostata* group, there would be no purpose in departing from Stewart's view. But to maintain it is to put more than a hundred years of common usage needlessly into the wrong.

Mlle. Gillet (1924) showed that the species of *Neithea*, as here understood, fall into two well-marked groups. The members of the larger group have equal or subequal ears, and include both *N. quinquecostata* and *N. aequicostata*. The species of the second group have very unequal triangular ears, as in *N. quadricostata* Sowerby. Stewart considered that his subgenus *Neitheops* should not include the forms with unequal ears, and that these might even merit generic distinction. Apparently Drouet was also of this mind, because he did not include *N. quadricostata* among his original species of *Neithea*, though he must have been familiar with it. The species has usually been ranked as a *Vola* or *Janira*, both invalid names. The unusual feature of this and similar forms, however, is that it is the *posterior* ear which is the larger, and Davenport's exhaustive contributions to this subject (1903, especially p. 135) dispose of any suggestion that this feature can rank more than specifically. Whatever they be called, therefore, Mlle. Gillet's two "groups" are cogeneric.

Subgenus HYALOPECTEN Verrill, 1897

Connecticut Acad. Arts and Sci. Trans., vol. 10, pt. 1, p. 71

Verrill made an original designation of type as his own *P. undatus*, 1885. This name was preoccupied by Defrance (1825, p. 257), but Verrill's species has to the best of the author's knowledge never been renamed. Fortunately, it may not be necessary to add another specific name to the literature. The whole of Verrill's discussion of his new genus and species, however, has become obscured behind a riot of synonyms and junior homonyms, and it is necessary to clarify these in order to name the genotype.

As further examples of his new genus, Verrill mentioned *P. fragilis* Jeffreys, *P. pudicus* E. A. Smith, and *P. dilectus* Verrill & Bush. Jeffreys' original diagnosis of *P. fragilis* (1876, p. 424) is unaccompanied by a figure, but the description is very clear. It makes the species a small form with small, broad, equal ears. The upper valve has 15 to 20 concentric folds which do not reach the sides of the shell. Three years later (1879, p. 561), Jeffreys again described *P. fragilis*, and also figured it (pl. 45, fig. 1). He did not say what his two drawings represented, but they clearly show the interior and exterior of a right or lower valve. It is quite unlike the description of 1876, having very unequal ears with a considerable byssal notch, and only 11 concentric folds which reach fully to the sides of the shell.

Verrill realized that Jeffreys had described two distinct species, and rightly held the 1876 description to represent the true *P. fragilis*. Dall, however, regarded the figures of 1879 as representing the species. He accordingly produced the new name *P. eucymatus* (1898, p. 754) for "*P. fragilis* Verrill, non Jeffreys." Since Verrill was correct in this instance, and Dall's contumely was undeserved, *P. eucymatus* is an exact synonym of *P. fragilis* Jeffreys. Moreover, the latter was itself a preoccupied name (Defrance, 1825, p. 251), and had already been renamed *P. biscayensis* by Locard (1888, p. 144). Thus the valid name for Jeffreys' species is *P. biscayensis*, and the figured "*P. fragilis*" of 1879 is still without a name.

Verrill's original description of his *P. undatus* made it quite indistinguishable from the figured "*P. fragilis*." The description was accompanied by a drawn figure (pl. 44, fig. 21) and this figure, of a left valve, was reproduced in the 1897 paper (pl. 18, fig. 5). The valve has 12 or 13 folds, and so is quite unlike the original *P. fragilis* (*biscayensis*). It was perhaps the fact that Verrill figured a left valve, and Jeffreys a right valve, that helped to mislead Dall and others. Furthermore, the species *H. dilectus* Verrill & Bush (1897, p. 80) is indistinguishable from *H. undatus*, and just like Jeffreys' figures of the false "*P. fragilis*." Dall himself was satisfied that the latter was conspecific with both *H. undatus* and *H. dilectus*. (1898, p. 754). Thus the valid name for the genotype of *Hyalopecten* (and also for the species figured by Jeffreys) is *Hyalopecten dilectus* Verrill & Bush.

The synonymy of the two species now appears to be as follows:

HYALOPECTEN DILECTUS Verrill & Bush

Pecten fragilis JEFFREYS, 1879, Zool. Soc. London Proc., p. 561, pl. 45, fig. 1.

NOT *Pecten fragilis* JEFFREYS, 1876, Annals and Mag. Nat. History, 4th ser., vol. 18, p. 424 (=*P. biscayensis* LOCARD, Genre Pecten, 1888, p. 144; Gulf of Gascogne).

NOT *Pectinites fragilis* SCHLOTHEIM, 1820, Die Petrefaktenkunde auf ihrem jetzigen Standpunkte, Gotha, p. 225.

NOT *Pecten fragilis* DEFRANCE, 1825, Dictionnaire des Sciences naturelles, vol. 38, p. 251.

Pecten undatus VERRILL & SMITH, 1885, Connecticut Acad. Arts and Sci. Trans., vol. 6, p. 444, pl. 44, fig. 21. Type locality: Station 2229, Albatross Expedition (off Chesapeake Bay), in 1423 fathoms.

Hyalopecten undatus VERRILL, 1897, Connecticut Acad. Arts and Sci. Trans., vol. 10, p. 71, pl. 18, fig. 5.

NOT *Pecten undatus* DEFRANCE, 1825, Dictionnaire de Sciences naturelles, vol. 38, p. 257.

Hyalopecten dilectus, VERRILL & BUSH, 1897, Connecticut Acad. Arts and Sci. Trans., vol. 10, p. 80. Type locality: Station 2570, Albatross Expedition of 1885 (off Martha's Vineyard), in 1813 fathoms.

HYALOPECTEN BISCAYENSIS Locard, 1888

Pecten fragilis, JEFFREYS, 1876, Annals and Mag. Nat. History, 4th ser., vol. 18, p. 424.

NOT *Pecten fragilis*, JEFFREYS, 1879, Zool. Soc. London Proc., p. 561, pl. 45, fig. 1 (=*Hyalopecten dilectus* VERRILL and BUSH, 1897).

NOT *Pectinites fragilis* SCHLOTHEIM, 1820, Die Petrefaktenkunde auf ihrem jetzigen Standpunkte, Gotha, p. 225.

NOT *Pecten* fragilis, DEFRANCE, 1825, Dictionnaire de Sciences naturelles, vol. 38, p. 251.

Pecten biscayensis LOCARD, 1888, Contribution à la faune malacologique française, Pt. 11: Monographie des espèces appartenant au Genre *Pecten*, Lyon, p. 144. Living, Gulf of Gascogne.

Hyalopecten fragilis (JEFFREYS) VERRILL, 1897, Connecticut Acad. Arts and Sci. Trans., vol. 10, p. 81.

Pecten aucymatus DALL, 1898, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 754. New name for "*P. fragilis* VERRILL, non JEFFREYS."

Genus EBURNEOPECTEN Conrad, 1865

Am. Jour. Conchology, vol. 1, p. 140, pl. 10, fig. 4

Type by monotypy:—Pecten scintillatus Conrad, 1865.

Conrad's figure is of a young shell from the Eocene of Enterprise, Mississippi. A better illustration was given by Harris (1896, p. 470, pl. 18, figs. 1, 2). Having created the name *Eburneopecten*, Conrad himself withdrew it in the same paper (p. 190b) as being a synonym of *Camptonectes* Meek, 1864. *Camptonectes* however, is typically a Mesozoic genus, the type, *C. lens* Sowerby (1818, p. 3, pl. 205, figs. 2, 3), coming from the Argovian of Oxford, England. Considerations of secondary ornament apart (and the "*Camptonectes*-sculpture" is not the generic character, being prominent in several pectinid genera), *Eburneopecten* is certainly not exactly synonymous with *Camptonectes*, and too many subsequent authors have too uncritically accepted it as such.

On the other hand, it may be synonymous with *Pseudentolium* Cox, 1948 (p. 63). Consideration of this, however, must await further study, but it is probable that *Pseudentolium* will have to be abandoned.

REFERENCES

ADAMS, H. and ADAMS, A., 1858, The genera of Recent Mollusca, arranged according to their organisation, vol. 2. London, Van Voorst.

ARNOLD, R., 1906, The Tertiary and Quaternary pectens of California: U. S. Geol. Survey Prof. Paper 47.

CHEMNITZ, J. H., and MARTINI, F. W. H., 1769–1795, Neues systematisches conchylien-cabinet, vols. 1–11. Nürnberg, Bauer and Raspe.

CHENU, J. C., 1862, Manuel de conchyliologie, vol. 2. Paris, Librairie Victor Masson.

COSSMAN, A. E. M., and PEYROT, A., 1914, Conchologie Néogénique de l'Aquitaine, vol. 2, pt. 2: Soc. linnéenne Bordeaux Actes, vol. 68, pt. 1.

COX, L. R., 1948, Neogene Mollusca from the Dent Peninsula, British North Borneo: Schweizer. Paleont. Abh., vol. 66, pp. 1–70.

DALL, W. H., 1896, Reports on the results of dredging by the U.S.C.S. Steamer Blake, XXIX, Report on the Mollusca, pt. 1, Brachiopoda and Pelecypoda: Mus. Comp. Zool. Bull., vol. 12, no. 6.

——, 1898, The Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 4.

DAVENPORT, C. B., 1903, Quantitative studies in the evolution of *Pecten:* Am. Acad. Arts Sci. Proc., vol. 39, pp. 124–159.

DILLWYN, L. W., 1817, A descriptive catalogue of Recent shells. London, J. and A. Arch.

FISCHER, P., 1886, Manuel de conchyliologie et de paléontologie conchyliologique, pt. 10, pp. 942–947. Paris, Librairie F. Savy.

GILLET, S., 1924, Révision du sous-genre *Neithea* Drouet: Soc. géol. France Bull., 4th ser., t. 24, pp. 115–122.

GRANT, U. S., IV, and GALE, H. R., 1931, Catalogue of the marine Pliocene and Pleistocene Mollusca of California: San Diego Soc. Nat. History Mem., vol. 1.

GRAY, J. E., 1847, Genera of Recent Mollusca, their synonyma and types: Zool. Soc. London Proc., pt. 15, pp. 200–201.

HARRIS, G. D., 1896, New and interesting Eocene Mollusca from the Gulf states: Acad. Nat. Sci. Philadelphia Proc., pp. 470–482.

HERRMANNSEN, A. N., 1847, Indicis generum malacozoorum Primordia, pt. 2. Cassel, Theodore Fischer.

JEFFREYS, J. G., 1876, New and peculiar Mollusca of the Pecten, Mytilus, and Arca families procured in the "Valorous" Expedition: Annals and Mag. Nat. History, 4th ser., vol. 18.

——, 1879, On the Mollusca procured during the "Lightning" and "Porcupine" Expeditions, 1868–70, pt. 2: Zool. Soc. London Proc., pp. 556–562.

KOBELT, W., 1881, Illustrirtes Conchylienbuch, vol. 2. Nürnberg, Erlangen.

LAMARCK, J. B. P. A., 1819, Histoire naturelle des animaux sans vertèbres, vol. 6. Paris, Verdière.

LOCARD, A., 1888, Contribution à la faune malacologique française, pt. 2, Monographie des espèces appartenant au genre *Pecten:* Soc. linnéenne Lyon Annales, n.s., t. 34.

MARWICK, J., 1928, The Tertiary Mollusca of the Chatham Islands: New Zealand Inst. Trans., vol. 58, pt. 4.

MÖRCH, O. A. L., 1853, Catalogus conchyliorum quae reliquit D. Alphonso d'Aguirra et Gadea comes de Yoldi, fasc. 2.

PHILIPPI, E., 1900, Beiträge zur Morphologie und Phylogenie der Lamellibranchier, pt. 2, Zur Stammesgeschichte der Pectiniden: Zeitschr. deutsch. geol. Gesell., Bd. 52, pp. 64–117.

REEVE, L. A., 1852–53, Conchologia Iconica, vol. 8, Monograph of the genus *Pecten*. London, privately published.

ROWLAND, H. I., 1938, The Atlantic and Gulf Coast Tertiary Pectinidae of the United States, pt. 3: Mus. royale histoire nat. Belgique, 2d

ser., fasc. 13.
SOWERBY, G. B., 1842–1843, Thesaurus conchyliorum, vol. 1, Monograph of the genus *Pecten*, pp. 45–82. London, Van Voorst.
SOWERBY, J., 1814–1818, The mineral conchology of Great Britain, vols. 1 and 3. London, privately published.
STEWART, R. B., 1930, Gabb's California Cretaceous and Tertiary type Lamellibranchs: Acad. Nat. Sci. Philadelphia Special Pub. 3, pp. 115–124.
STOLICZKA, F., 1871, The Cretaceous fauna of southern India, vol. 3, The Pelecypoda: Palaeontologia Indica, 6th ser., vol. 3, Geol. Surv. India Mem.
SUTER, H., 1913, Manual of the New Zealand Mollusca. Wellington, New Zealand Geol. Survey.
TEPPNER, W. VON, 1922, Lamellibranchiata tertiaria, Anisomyaria, 2, Fossilium Catalogus, I, Animalia, pt. 15. Berlin, W. Junk.
THIELE, J., 1934, Handbuch der systematischen Weichtierkunde, t. 3. Jena, Fischer.
VERRILL, A. E., 1885, Third catalogue of Mollusca recently added to the fauna of the New England coast, etc.: Connecticut Acad. Arts Sci. Trans., vol. 6, art. 10.
—— 1897, A study of the family Pectinidae, with a revision of the genera and sub-genera: Connecticut Acad. Arts Sci. Trans., vol. 10, pt. 1.
WOOD, S. V., 1861, A monograph of the Eocene Mollusca, pt. 1, Bivalves: Palaeontographical Soc. London, pp. 36–47.
WOODRING, W. P., 1925, Miocene mollusks from Bowden, Jamaica: Carnegie Inst. Washington Pub. 366.

CORRECTIONS: RECENT PAPERS ON MESOZOIC AND CENOZOIC OSTRACODA[1]

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1. Swartz, F. M. and Swain, F. M., "Ostracoda from the Upper Jurassic Cotton Valley group of Louisiana and Arkansas," Jour. Paleontology, 1946, vol. 20, pl. 52, figs. 1, 2. Figure 2 is the holotype of *Schuleridea acuminata* Swartz & Swain, n. gen., n. sp.; figure 1 is a paratype.

2. Swain, F. M., "Ostracoda from the Tertiary of Florida," Jour. Paleontology, 1946, vol. 20, p. 379, pl. 54, figs. 14a–e, pl. 55, figs. 5a, b. *Leguminocythereis? corrugata* Swain, n. sp. is a homonym of *Leguminocythereis corrugata* LeRoy (Jour. Paleontology, 1943, vol. 17, p. 372, pl. 59, figs. 7–12, pl. 62, figs. 7, 8, p. 362, text-fig. x). This error was pointed out to me in 1948 by James A. Peterson, graduate student at the University of Minnesota and by L. W. LeRoy (personal communication, 1949). *Leguminocythereis? petersoni* Swain, new name, is here proposed to replace *L.? corrugata* Swain (not LeRoy).

3. Swain, F. M., "Tertiary nonmarine Ostracoda from the Salt Lake formation, northern Utah," Jour. Paleontology, vol. 21, 1947, p. 518, column 2, line 15, for *Iliocypris* Sars read *Ilyocypris* Brady & Norman, 1889.

4. Swain, F. M., "Early Tertiary Ostracoda from the western interior United States," Jour. Paleontology, 1949, vol. 23, p. 179, pl. 33, figs. 10–12. H. V. Howe kindly pointed out to me that *Ilyocypris arvadensis tuberculata* Swain is a homonym of *I. gibba tuberculata* Brady (Linnean Soc. London Trans., 1868, vol. 26, pt. 2, p. 483, pl. 4, fig. 54). The name *Ilyocypris arvadensis linonodosa* Swain, new name, is here proposed for the variety described by me from the Paleocene, roof of Roland coal, SE$\frac{1}{4}$ sec. 13, T. 9 S., R. 45 E., Powder River County, Montana.

In the same publication, I suggested that *Cypris granulosa* Sowerby be considered the type of *Cypridea* Bosquet. I overlooked the fact that in 1947 P. C. Sylvester-Bradley had made the same designation, in an abstract of a paper presented before the Geological Society of London (Geol. Soc. London Quart. Jour., 1947, vol. 103, p. viii).

5. Swain, F. M., "Ostracoda from the Hammond Well," in Anderson, F. L., "Cretaceous and Tertiary Subsurface Geology," Maryland Dept. Geol., Mines and Water Res. Bull. 2, 1948, p. 210, pl. 14, fig. 15. H. V. Howe informed me (personal communication, 1950) that *Cytheridea* (*Haplocytheridea*) *obovata* Swain is a homonym of *Cytheridea obovata* Jones & Sherborn (Bath Nat. Hist. and Antiq. Field Club Proc., 1888, vol. 6, p. 264, pl. 2, figs. 6a–c). To conform with present recognition of *Haplocytheridea* Stephenson as a distinct genus, my species from the Miocene of Maryland is here renamed *Haplocytheridea hammondensis* Swain, new name.

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PEALERINA, NEW NAME, REPLACING *ELLISINA* LALICKER

CECIL G. LALICKER
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Mr. H. Dighton Thomas of the British Museum (Natural History) has kindly advised me of the preoccupation of *Ellisina*, a name proposed by me (1950, p. 18) for a genus of Foraminifera. This name has been used previously by Norman (1903, p. 596) for a genus of Bryozoa. As a replacement I propose *Pealerina*, genotype *P. spatula* (Lalicker).

REFERENCES

LALICKER, CECIL G., 1950, Foraminifera of the Ellis group, Jurassic, at the type locality: Univ. Kansas Paleont. Contr., Protozoa, Art. 2, pp. 3–20.

NORMAN, A. M., 1903, Notes on the natural history of East Finmark: Annals and Mag. Nat. History, ser. 7, vol. 11, pp. 567–598.

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REVIEW

REPORT OF 18TH SESSION, INTERNATIONAL GEOLOGICAL CONGRESS: PT. 1, GENERAL PROCEEDINGS, 225 pp; PT. 12, PROCEEDINGS OF SECTION L, EARTH MOVEMENTS AND ORGANIC EVOLUTION, 59 pp; PT. 15, PROCEEDINGS OF THE INTERNATIONAL PALEONTOLOGICAL UNION, 86 pp. London, 1950. (Not available separately.)

In addition to proceedings of the general sessions of the Congress, part 1 contains papers on the structural history of England, Wales and Scotland.

Part 12 consists of five papers: "Orogenic movements, sedimentation and evolution of life in the western Carpathians" by D. Andrusov (in French), "Paleozoic earth movements and organic evolution" by L. V. Čepek, "On the causes of certain faunal migrations before and during the Eocene" by A. Cavan (in French), "Evolution of the Crinoidea in relation to major paleogeographic changes in earth history" by R. C. Moore, and "Geochemistry, rhythms of sedimentation and organic evolution in the light of techtogenesis" by J. Zapletal (in German). The subject of this symposium was evidently much too ambitious and, in spite of these titles none of the contributions is particularly pertinent. Moore's paper is probably the most important. It summarizes his views on crinoid evolution but makes no attempt to relate this to earth movements or history. Aside from data, presented in charts, showing geographic and stratigraphic ranges of genera and the introduction of a few morphologic terms it contains little that is new.

Part 15 consists of the proceedings of three meetings of the Paleontological Union and three symposia. The first symposium, "Special aspects of paleontological publication," includes six papers reporting on current avenues of publication and suggestions or plans for the establishment of centers of information and documentation. The second "The uses of Foraminifera in stratigraphical paleontology," consists of the following papers: "The uses of Foraminifera in lower Jurassic stratigraphy" by T. Barnard, "Foraminifera as guide fossils in the Upper Cretaceous especially of northwest Germany" by H. Hiltermann (in German), "Micropaleontology and stratigraphy in the Tertiary Basin and Flysch zone of Austria" by R. Grill (in German), "Stratigraphy of the Caenozoic of the East Indies based on the Foraminifera" by I. M. van der Vlerk, "Foraminifera in Australian stratigraphy" by Irene Crespin, "The stratigraphical value of Foraminifera in New Zealand" by C. D. Ovey, and "Foraminifera and the stratigraphy of the Indo-Afghan border" by L. M. Davis. Three others papers are included in abstract only. The third symposium, "Paleontological Nomenclature," includes a report by Francis Hemming on "Reforms in zoological nomenclature adopted by the Thirteenth International Congress of Zoology in Paris, July, 1948" and a suggestion by L. Strausz regarding the use of quadrinomial nomenclature. The former is of considerable interest as it indicates the direction that is being taken in revision of the International Rules of Zoological Nomenclature which may be approved by the next Zoological Congress.

J. M. W.

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Compton—
Fritz, Edward B.
Stevenson, Robert E.
El Monte—
Fleming, Frederick A.
Encino—
Campbell, David G.
Glendale—
Cross, Zilda M.
Hanford—
Gribi, Edward A., Jr.
Hollister—
Turner, Francis E.
La Canada—
Siegfus, Stanley S.
La Jolla—
Frautschy, Jeffery Dean
Inman, Douglas L.
Norris, Robert M.
Parker, Frances L.
Revelle, Roger
Shepard, Francis P.
Long Beach—
Crouch, Robert W.
Elliott, Wayne
Hurley, Myrl W.
Kuffel, George C.
Los Angeles—
Bandy, Orville L.
Barnard, Ralph M.
Bramlette, M. N.
Clements, Thomas
Corey, William Henry
Driver, Herschel L.
Easton, William H.
Emery, Kenneth O.
Gilluly, James
Goudkoff, Paul P.
Gould, Howard R.
Grant, U. S., IV
Hamill, James M.
Jurin, Nicholas V.
Laiming, Boris
Loel, Wayne
Melnikoff, Tikhon P.
Michelin, James
Parker, Frank S
Rankin, Wilbur D.
Riccio, Joseph F.
Riveroll, David D.
Simon, Louis J.
Simonson, Russell R.
White, R. T.
Wissler, S. G.
Menlo Park—
Sturz, Charles E.
Mission Beach—
Ludwick, John C.
Oakland—
Kleinpell, Robert M.
Trask, Parker D.
Ojai—
Armstrong, Ursel S.
Orange—
Knight, Raymond L.
Pacific Palisades—
Traxler, J Douglas
Palo Alto—
De Lara, Fernando
Harrington, George L.
Pasadena—
Adams, Bradford C.
Israelsky, Merle C.
Lee, A. Theodore
Stauffer, Clinton R.
Thalmann, Hans E.
Paso Robles—
Tarbet, Loyal A.
Rolling Hills—
Natland, M. L.
Rosemead—
Anderson, Howard T.
San Diego—
Buffington, Edwin C.
Carsola, Alfred J.
Dietz, Robert S.
Menard, Henry W., Jr.
Russell, R. Dana
San Francisco—
Barbat, William F.
Church, Clifford C.
Hanna, G Dallas
Stach, Leo W.
Wade, F. Alton
Weymouth, A. Allen
San Rafael—
Bettinger, Charles E.
Leith, Carlton J.
Santa Maria—
Hughes, Aden W.
Stanford University—
Graham, Joseph J.
Kelley, Frederic R.
Levorsen, A. I.
Schenck, Hubert G.
Stockton—
Waldo, A. W.
Temple City—
Gilbert, Orrin W.
Upland—
Taylor, Dwight W.
Van Nuys—
Slosson, James E.
Ventura—
Carson, Carlton M.
Whittier—
Braislin, Dana B., Jr.
Reade, Harry L., Jr.
White, William R.

COLORADO

Boulder—
Chronic, John
Lease, Leslie W.
Thompson, Warren O.
Toepelman, Walter C.
Denver—
Bass, N. Wood
Bramlette, W. A.
Crowley, A. J.
Downs, George R.
Finley, Emmett A.
Mielenz, Richard C.
Pfeiffer, David H.
Robeck, Raymond C.
Tanner, Joseph J.
Golden—
Gurel, Mehmet
Hughes, R. J., Jr.
Johnson, J. Harlan
LeRoy, Leslie W.
Mateer, Warren D.
Grand Junction—
Cadigan, Robert A.
Rocky Ford—
Russom, Vaughn W

CONNECTICUT

Hartford—
Stone, Solon W.
New Haven—
Dunbar, Carl O.

DISTRICT OF COLUMBIA

Washington—
Applin, Esther R.
Bassler, R. S.
Bowles, Edgar O.
Chappars, Michael S.
Cobban, William A.
Cohee, George V.
Cooper, Chalmer L.
Dante, John Henry
Gardner, Julia
Goldman, Marcus I.
Gordon, MacKenzie, Jr.
Hawkins, Harold H.
Henbest, Lloyd G.
Knight, J. Brookes
Loeblich, Alfred R., Jr.
Manger, G. E.
McIntyre, John B.
Miser, Hugh D.
Nicol, David
Payne, Thomas G.
Péwé, Troy L.
Rubey, William W.
Schmidt, Ruth A. M.
Sohn, I. G.
Vaughan, T. Wayland
Williams, James Steele
Williams, John R.
Wrather, W. E.

FLORIDA

Orlando—
Twenhofel, W. H.
Plant City—
Cathcart, James B.
Tallahassee—
Caldwell, Eleanor T.
Raasch, Albert C., Jr.

IDAHO

Moscow—
Youngquist, Walter L.

ILLINOIS

Champaign—
Boardman, Richard S.
Hayes, Margaret A.
Cherry—
Kraye, Robert Frank
Chicago—
Emiliani, Cesare
Greenman, Norman N.
Harges, Marvin E.
Kawakami, Noboru
Koucky, Frank Louis, Jr.
Krinsley, David H.
Lowenstam, Heinz A.
Otto, George H.
Pettijohn, F. J.
Seltin, Richard J.
Sloan, Robert Evan
Weller, J. Marvin
Winterbotham, John Russell, III
Effingham—
Bristol, Hubert M.
Evanston—
Dapples, Edward C.
Gutstadt, Allan M.
Krumbein, W. C.
Sloss, Laurence L.
Galena—
Herbert, Paul, Jr.
Mt. Vernon—
Brehm, Clarence E.
Rosiclare—
Sutton, A. H.
Salem—
Allison, James M.
Hockman, James N.
Urbana—
Hough, Jack Luin
Kummel, Bernhard
Mann, John F., Jr.
Scott, Harold W.
Wanless, Harold R.
Wilson, George M.

INDIANA

Bloomington—
Galloway, J. J.
Lafayette—
Serviss, Fred L.
Notre Dame—
Gutschick, Raymond C.

IOWA

Ames—
Hussey, Keith M.
Brandon—
Stainbrook, Merrill A.
Iowa City—
Jeffords, Russell M.
Miller, A. K.
Tester, Allen C.
Trowbridge, A. C.

KANSAS

Fowler—
Skinner, John W., Jr.
Independence—
Studt, Charles W.
Lawrence—
Chakravorty, Sailendra K.
Davis, Stanley N.
Fay, Robert O.
Fischer, Alfred G.
Frye, John C.
Ireland, Hubert A.
Lalicker, Cecil G.
Locker, Walter A., Jr.
Moore, Raymond C.
Swineford, Ada
Manhattan—
Byrne, Frank E.
Wichita—
Berg, J. Robert
Blythe, Jack Gordon
Carmody, Robert A.
Koester, Edward A.
Walters, Robert F.
Wood, Elmer

LOUISIANA

Baton Rouge—
Brown, Charles E.
Howe, Henry V.
Macomber, Donald, Jr.
Murray, Grover E.
Pittman, James S., Jr.
Sexton, James V.
Tator, Benjamin A.
Wilbert, Louis J., Jr.
Franklin—
Boudreaux, Marvin D.
Boudreaux, Warren J.
Thompson, Warren C.
Harvey—
Smith, Denver J.
Lafayette—
Varvaro, Gasper Gus
Wiley, Richard A.
Lake Charles—
Anderson, Irvin J.
Camacho, Enrique
Clark, Robey H.
Latta, Lee Allen
Morrow, A. Lyndon
Stevenson, Frank V.
Tipsword, Howard Lee
Morgan City—
Brophy, John Allen
New Orleans—
Akers, Wilburn H.
Everett, Robert W., Jr.
Seashore, P. T.
Thomson, Marion R.
Shreveport—
Caldwell, Barbara Summerill
Craver, Frank S., Jr.
Hazzard, Roy T.
Henton, John Melvin, Jr.
Hickcox, Charles A.
Moody, Clarence L.
Philpott, Thomas H.
Robinson, Van D.
Schiemenz, Albert M.
Scott, Edward W.

MAINE

Lewiston—
Fisher, Lloyd W.
Orono—
Trefethen, Joseph M.

MARYLAND

Bethesda—
Stephenson, Lloyd W.
Chevy Chase—
Ladd, Harry S.
Hyattsville—
Reeside, John B., Jr.

MASSACHUSETTS

Amherst—
Wilson, Leonard R.
Cambridge—
Barghoorn, Elso Sterrenberg
Hartshorn, Joseph H.
Shrock, Robert R.
Stetson, Henry C.
Northampton—
Shaub, Benjamin M.
South Hadley—
Said, Rushdy
Williamstown—
Ramsdell, Robert C.

MICHIGAN

Ann Arbor—
Kellum, Lewis B.
Detroit—
Sanford, John T.
East Lansing—
Kelly, William A.
Oscoda—
Bostwick, David A.

MINNESOTA

Minneapolis—
Eisenberg, Marvin
Ellinwood, H. L.
Goldich, Samuel S.
Lindblom, Robert Grant
Swain, Fred M.
Northfield—
Stewart, Duncan

MISSISSIPPI

Jackson—
Bilberry, Charles G.
Braunstein, Jules
Holden, Frederick T.
Martin, James L., Jr.
Mather, Katharine

Monsour, E. T.
Sellin, H. A.
Laurel—
Hughes, Urban B.

MISSOURI

Columbia—
Keller, W. D.
Peck, Raymond E.
Ferguson—
Echols, Dorothy Jung
Kansas City—
Greene, Frank C.
Rolla—
Frizzell, Don L.
Higgs, William R.
St. Louis—
Hinchey, Norman S.
Levinson, Stuart A.
Nadeau, Betty Kellett

MONTANA

Billings—
Darrow, George F.
Sanders, John Warren
Sonnenberg, Frank P.
Butte—
Hanson, Alvin M.
Lewistown—
Beekly, Emerson K.
Miles City—
Dunham, Robert J.

NEBRASKA

Lincoln—
Elias, Maxim K.
Lugn, Alvin L.
Reed, Eugene C.

NEW JERSEY

New Brunswick—
Donohue, John J.
Martens, James H. C.
Nine, Ogden W., Jr.
Princeton—
Hess, Harry H.
Howell, B. F.
Van Houten, Franklyn B.
Summit—
Pardo, Georges
West Englewood—
McMaster, Robert L.

NEW MEXICO

Albuquerque—
Smith, Ralph E.
Thorp, Eldon M.
Wengerd, Sherman A.
Jal—
Taylor, Warren L.
Roswell—
Ley, Ross Henry
Winkler, Hans

NEW YORK

Albany—
Grossman, I.
Brooklyn—
Wang, Kia-Kang
Buffalo—
Hibbard, Raymond R.
Ithaca—
Palmer, Katherine V. W.
Ries, Heinrich
New York—
Bradley, John S.
Bush, James
Coryell, Horace N.
Ellis, Brooks Fleming
Hedberg, Hollis D.
Jablonski, Eugene
Kaufmann, Godfrey F.
Kay, Marshall
King, Robert Evans
Martin, Lewis
Messina, Angelina R.
Newell, Norman D.
Salvador, Amos
Poughkeepsie—
Warthin, A. S., Jr.
Rochester—
Alling, Harold L.
Rye—
Brixey, Austin Day, Jr.
Syracuse—
Apfel, Earl T.
Troy—
Beers, Roland F.
Lowman, Shepard W.

NORTH CAROLINA

Chapel Hill—
Ball, John Rice
Powers, Maurice C.

NORTH DAKOTA

Fargo—
Pye, Willard D.

OHIO

Athens—
Abbott, Ralph E.
Sturgeon, Myron T.
Cincinnati—
Caster, Kenneth E.
Lattman, Laurence Harold
Martin, Wayne D.
Rittenhouse, Gordon
Columbus—
Frazier, Noah A.
Schopf, James M.
Spieker, Edmund M.
Summerson, Charles H.
Oxford—
Anderson, Gerald K.
Youngstown—
Jordan, Louise

OKLAHOMA

Ardmore—
Gill, J. P.
Hicks, I. Curtis
Johnson, William R.
Jones, Fred B., Jr.
Neustadt, Walter, Jr.
Nichols, Herman E., Jr.
Parker, Everett C.
Tomlinson, Charles W.
Westheimer, Jerome Max
White, Maynard P.
Bartlesville—
Ewbank, Norman Ware, Jr.
Strimple, H. L.
Weeks, Warren B.
Chickasha—
Bryan, J. Victor
Duncan—
Huff, Jack Newton
Putman, Darrel M.
Enid—
Baker, Vernon R.
Clifton, R. L.
Muir, J. Lawrence
Muskogee—
Wallace, Maurice H.
Norman—
Branson, Carl C.
Culp, Eugene F.
Decker, Charles E.
Frederickson, Edward A.
Huffman, George G.
Lohman, Clarence, Jr.
Lucas, Elmer Lawrence
Moore, Carl A.
Oklahoma City—
Connolly, Frank T.
Eisner, Stephan M.
Hurry, Floyd Phillip
Isbell, Grover Jim
Kate, Frederick H.
McGee, Dean A.
Moreman, Walter L.
Pasquella, George G.
Pollard, Robert T.
Richards, J. T.
Schweers, Frederick Paul
Turk, Lon B.
Whistler, Rex
Wimbish, Forrest Edwin
Purcell—
Richardson, Colonel A., Jr.
Shawnee—
Blllingsley, Harold Ray
Tanner, William F.
Stillwater—
Naff, John D.
Stilwell—
Hicks, Forrest L.
Tulsa—
Bennison, Allan P.
Branson, Herberta Van Pelt
Cruse, John S., Jr.
Denison, A. Rodger
Elias, Gregory K.
Feray, Dan Edwards
Gibson, William C.
Goldstein, August, Jr.
Grigsby, R. B.
Griley, H. L.
Harlton, Bruce H.
Harris, Steven H.
Hawkins, Glenn D.
Kauffman, James S.
Kjellesvig-Waering, Erik N.
Marshall, Lester Ray
Porterfield, Robert R.
Reeves, James E.

Riggs, R. J.
Ryniker, Charles
Travis, Richard
Upp, Jerry E.
Wagner, Carl D.

OREGON

Corvallis—
Boyd, Harold A., Jr.
Portland—
Rau, Weldon W.
Stewart, Roscoe Emerson

PENNSYLVANIA

Bethlehem—
Willard, Bradford
Bird-in-Hand—
Moss, John Hall
Bryn Mawr—
Jaekel, Julie Anne Klovstad
Kennett Square—
Folk, Robert L.
Langhorne—
Olsson, A. A.
Philadelphia—
Kammerer, John Craig
Weeks, H. J.
Pittsburgh—
Bayles, Robert E.
Cox, Ben B.
Fettke, Charles R.
State College—
Bressler, Calder T.
Griffiths, J. C.
Krynine, Paul D.
Swartz, Frank M.

SOUTH DAKOTA

Rapid City—
Tullis, Edward L.

TENNESSEE

Knoxville—
Eveland, Harmon E.

TEXAS

Abilene—
Conselman, Frank B.
Fountain, H. C.
Grubbs, David M.
Morrison, Robert E.
Alpine—
Cox, Charles Lynwood, Jr.
Amarillo—
Britt, Harry M., Jr.
Spencer, Maria
Whipple, G. Leslie
Arlington—
McNulty, Charles Lee, Jr.
Austin—
Barnes, Virgil E.
Brand, John Paul
Damon, H. Gordon
Eargle, D. Hoye
Eifler, G. K., Jr.
Ellison, Samuel P., Jr.
Gaines, Robert B., Jr.
Gimbrede, Louis de A.
Humble, Emmett A.
Lonsdale, John T.
Lundelius, Ernest L., Jr.
Matthews, William H., III
Ripple, Alfred L.
Stenzel, H. B.
Twining, John T.
Whitney, F. L.
Wilson, James Lee
Beaumont—
Strachn, Clarence H., Jr.
Bellaire—
Holliday, Samuel
Setzer, Francis M.
Coleman—
Cheney, M. G.
College Station—
Lynch, Shirley A.
Smith, Fred E.
Corpus Christi—
Holcomb, Charles W.
Olson, Walter S.
Owens, Frith Cravens
Ramsey, Patrick H.
Rogers, Arthur A.
Thomas, Norman L.
Dallas—
Albritton, Claude C., Jr.
Clark, John W.
DeGolyer, E.
Grant, Drane Fones
Hamilton, I. B.
MacNaughton, Lewis W.
Parsons, W. Frank
Sneed, Henry E.
Thompson, S. A.
Waters, James A.
El Paso—
Nelson, Lloyd A.
Encino—
Muil, Charles W.
Fort Worth—
Donoghue, David
Hendricks, Leo
Pfannkuche, Mrs. H. C.
Schweers, Richard Henry
Stewart, Wendell J.
Upson, M. E.
Winton, W. M.
Galveston—
Ellisor, Alva C.
Houston—
Adkins, W. S.
Albers, Charles C.
Baker, William A., Jr.
Bannahan, Annabelle Richardson
Bell, Olin G.
Bright, Anna Lou
Campbell, Curran R.
Carstens, Fred D.
Colle, Jack O.
Cotton, Edgar A.
Cram, Ira H.
Denham, Richard L.
Deussen, Alexander
Ellis, Albert D., Jr.
Ferguson, H. C.
Fisk, Harold N.
Garrett, J. B., Jr.
Gilkison, Dwight C.
Goodrich, Paul K.
Halbouty, M. T.
Halsted, Morris E.
Hanna, Marcus A.
Hayes, James F.
Hornberger, Joseph, Jr.
Horton, Ernest H.
Ikins, William C.
Kirby, Louie C.
Koenig, Karl J.
McLean, Clarence M., III
Malicoat, Arthur F.
Malkin, Doris S.
Martyn, Phil F.
Montgomery, J. C.
Moore, Jean Geisler
Morrison, T. E.
Nelson, Paul Hugh
Overton, Charles K.
Parker, William G.
Petrusek, Benjamin J.
Phillips, Henry H.
Pyeatt, Lloyd M.
Quigley, Claude M., Jr.
Reiter, W. A.
Ritts, L. Chase, Jr.
Rolshausen, F. W.
Sample, Charles Hurst
Sawin, Horace J.
Selig, A. L.
Stephenson, Morton B.
Stuckey, Charles W., Jr.
Tatum, Emmett P.
West, Glen D.
Westmoreland, Frank S.
Wood, Mary C.
Woods, Raymond D.
Lubbock—
Alexander, W. H., Jr.
Patton, Leroy T.
Sidwell, Raymond
Weart, Richard C.
McAllen—
Means, John Albert
Russo, Martin
Midland—
Adams, John Emery
Arick, Millard B.
Baker, Maylon S., Jr.
Caldwell, William S.
Douglass, Harry Marvin
Frenzel, Hugh N.
Hollingsworth, R. V.
Lewis, Jean
Meyer, Richard F.
Mills, Lloyd C.
Montgomery, James Harvey
Scobey, Ellis H.
Stead, Frederick L.
Williams, Harold L.
Zinser, Robert W.
Mineral Wells—
Chatham, E. Walter, Jr.
San Angelo—
Roper, Frank C.
San Antonio—
Alexander, C. I.
Drummond, Robert V.

Grasso, Volker C.
Morey, Philip S.
Owen, Edgar W.
Petty, Dabney E.
Rogers, James K.
Sandidge, John R.
Scrafford, John Bruce
Taylor, Jack A.

Seguin—
Kniker, Hedwig T.

Seymour—
Kemp, Augusta Hasslock

Tyler—
Hurlbut, Elvin M., Jr.

Wichita Falls—
Bradfield, Herbert H.
Drake, Robert T.
King, Ralph H.

UTAH

Salt Lake City—
Klemme, H. Douglas

VIRGINIA

Alexandria—
McLean, James D., Jr.

Falls Church—
Palmer, Allison Ralph

Lexington—
Stow, Marcellus H.

WASHINGTON

Pullman—
Mickelson, John Chester
Peterson, James A.

Seattle—
Coombs, Howard A.
Hamilton, Edwin Lee
Scott, W. Frank
Weaver, Charles E.
Wheeler, Harry E.

WISCONSIN

Beloit—
Croneis, Carey

Madison—
Sanderson, George A., Jr.
Thompson, M. L.
Tyler, Stanley A.
Zeller, Edward J.
Zimmerman, Donald A.

Platteville—
Agnew, Allen F.

Williams Bay—
Page, Lou Williams

WYOMING

Casper—
Barkell, Clifford A.
Reinhart, Philip
Snider, James Wilson
Swircyznski, Richard Paul

OUTSIDE THE UNITED STATES

ALASKA

Fairbanks—
Hamilton, C. E.

ALBERTA

Calgary—
Atkinson, Eric
Chilton, Mertie Ann
Doroshenko, Jerry
Fox, Frederick Glenn
Gleddie, Joseph
Goodman, A. J.
Nielsen, Arne R.
Wickenden, Robert T. D.
Williams, Edwin Philp
Wonfor, John S.

Edmonton—
Campbell, Robert B.

ALGERIA

Relizane—
Magne, Jean

AUSTRALIA

Canberra—
Crespin, Irene
Iten, Ken W. B.

Sydney—
Brown, Ida A.
Carroll, Dorothy

BELGIUM

Brussells—
Lombard, Augustin E.

Gand—
Tavernier, R.

Liège—
Calembert, Leon M. C.
Ubaghs, Georges J. C.

Rhode St. Genese—
Brognon, Georges P. G.

BORNEO

Balik-Papan—
Baggelaar, Hermanus

BRAZIL

Bahia—
Brantly, John E., Jr.

Rio de Janeiro—
Still, J. T.

BRITISH COLUMBIA

Vancouver—
Hughes, Richard David

BRITISH HONDURAS

Belize—
Flores, Giovanni

COLOMBIA

Barranca Bermeja—
Andrews, B. G.

Bogotá—
Gomez, Jose Royo y
Petters, Viktor
Schoonover, Jack Gardner

CUBA

Havana—
Acosta, Jose T.
Gravell, Donald W.
Pyre, Augustin

DENMARK

Copenhagen—
Flagler, C. W.

EGYPT

Cairo—
Arni, Paul
Iskander, Wassif
Shukri, N. M.
Souaya, Fernand J.

ENGLAND

Bristol—
Loupekine, I. S.

Cambridge—
Allen, Percival
Schwartacher, Walther
Sutherland, Pat K.

London—
van Bellen, Robert Carel

Melton Mowbray—
Baxter, George W.

Manchester
Eagar, Richard M. C.

Tenterden—
MacFadyen, W. A.

FRANCE

Bourg-la-Reine (Seine)—
Riviere, A.

Nancy—
Avias, Jacques

Paris—
Bourcart, J. J.
Cuvillier, Jean
de Cizancourt, Maria
Francis-Boeuf, Claude
Vatan, A.

Pau Bss. Pyr—
Sacal, Vincent

GERMANY

Celle—
Bentz, Alfred

Gottingen—
Correns, Carl W.

Hannover—
Sindowski, Karl-Heinz

INDIA

Calcutta—
Jacob, Kurien

Madras—
Kasthuri, A. K.

IRAN

Teheran—
Furrer, Max Adolph

IRAQ

Kirkuk—
Dunnington, Harold V.

ITALY

Florence—
Marchetti, Marco Piero
Merla, Giovanni
Migliorini, Carlo I.

Milano—
Alliata, Enrico di Napoli
Modena—
Gallitelli, E. Montanaro
Pisa—
Trevisan, Livio
Rome—
Fabiani, Ramiro

JAPAN

Kyoto—
Makiyama, Jiro
Sendai—
Hanzawa, Shoshiro
Hatai, Kotora
Tokyo—
Fujimoto, Haruyoshi
Kanehara, Kinji
Oinomikado, Tsuneteru
Sudo, Toshio

LEBANON

Tripoli—
Rabanit, Paul

MALAYA

Perak—
Alexander, J. B.

MEXICO

Mexico City—
Arellano, A. R. V.
Folk, Stewart H.
Mullerried, F. K. G.

NETHERLANDS

Amsterdam—
Rutten, Martin G.
Van Andel, Tjeerd Hendrik
Groningen—
Van Straaten, L. M. J. U.
Leiden—
Tromp, S. W.
Naarden—
Van Baren, F. A.
Oegstgeest—
Weynschenk, R.
Oldenzaal—
Bannink, Dirk D.
The Hague—
Emeis, J. D.
Hofker, Jan
Van Weelden, Arie
Utrecht—
Zinkstok, Johannes M.
Wageningen—
Doeglas, Dirk Jacobus

ONTARIO

Toronto—
Sproule, J. C.

PERSIAN GULF

Kuwait—
Hanks, Aubrey G. G.

PERU

Negritos—
Stainforth, Robert M.

PHILIPPINE ISLANDS

Lucena—
Daleon, Benjamin A.

PORTUGAL

Coimbra—
De Carvalho, G. Soares

SASKATCHEWAN

Regina—
Hilgers, C. L. L.

SAUDI ARABIA

Dhahran—
Eicher, Donald B.
Seager, O. A.

SCOTLAND

Edinburgh—
Higazy, Riad A.
Wright, James

SOUTHERN RHODESIA

Bulawayo—
Bond, Geoffrey

SPAIN

Soller (Balearic Islands)—
Colom, Guillermo

SUMATRA

Palembang—
Stone, Benton
Soengei Gerong—
Bruseker, T. J. M.
Wissema, G. G.

SWEDEN

Bromma—
Erdtman, Gunnar
Grodinge—
Arrhenius, Gustaf O. S.
Stockholm—
Mellis, Otto

SWITZERLAND

Basel—
Beckmann, Jean-Pierre
Tschopp, H. I.
Vonderschmitt, Louis
Binningen—
Schweighauser, Jacob
Fribourg—
Tercier, Jean
Lausanne—
Bersier, Arnold
Neuchatel—
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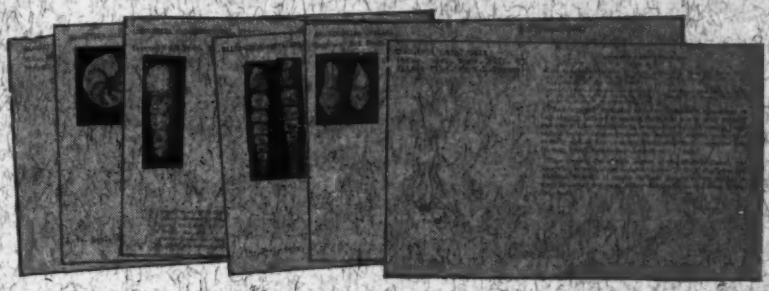

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